ExtrIQ

Hornet/Bee

Digital Servo Drives for

Extended Environmental Conditions

Installation Guide

February 2007 (Ver. 1.0)

Elmo
Motion Control

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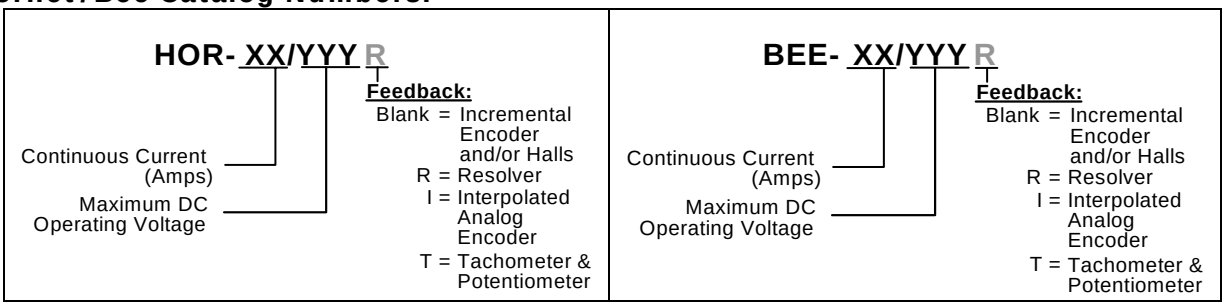

Related Products:

Evaluation Board Catalog Number	WHI-EVLBRD-1 (available upon request)
Evaluation Board User Manual	MAN-EVLBRD-WHI (available on our web site)

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Contents

Chapter 1: Safety Information 1-1
1.1 Warnings **1-2**
1.2 Cautions **1-2**
1.3 Directives and Standards **1-3**
1.4 CE Mark Conformance **1-3**
1.5 Warranty Information **1-4**
Chapter 2: Introduction 2-1
2.1 *ExtrIQ* Product Family **2-1**
2.2 Drive Description **2-2**
2.3 Product Features **2-3**
2.3.1 Current Control 2-3
2.3.2 Velocity Control 2-3
2.3.3 Position Control 2-3
2.3.4 Advanced Position Control *(in Advanced model only)* 2-3
2.3.5 Communication Options 2-4
2.3.6 Feedback Options 2-4
2.3.7 Fault Protection 2-4
2.4 System Architecture **2-5**
2.5 How to Use this Guide **2-5**
Chapter 3: Installation 3-1
3.1 Site Requirements **3-1**
3.2 Unpacking the Drives **3-1**
3.3 Pinouts **3-2**
3.3.1 Connector Types 3-2
3.3.2 Connector J1 3-3
3.3.3 Connector J2 3-4
3.4 Mounting **3-4**
3.4.1 Hornet 3-4
3.4.2 Bee 3-5
3.5 Integrating the Hornet or Bee on a PCB **3-6**
3.5.1 Traces 3-6
3.5.2 Grounds and Returns 3-6
3.6 The Hornet/Bee Connection Diagram **3-8**
3.7 Main Power and Motor Power **3-9**
3.7.1 Connecting Motor Power 3-9
3.7.2 Connecting Main Power 3-10
3.8 Auxiliary Supply (for drive logic) **3-10**
3.8.1 Single Supply 3-11
3.8.2 Separate Auxiliary Supply 3-11
3.8.3 Shared Supply 3-12
3.9 Main Feedback **3-13**
3.10 Auxiliary Feedback **3-17**

3.10.1 Main and Auxiliary Feedback Combinations 3-18
3.10.2 Auxiliary Feedback: Emulated Encoder Output Option (YA[4]=4) 3-19
3.10.3 Auxiliary Feedback: Single-Ended Encoder Input Option (YA[4]=2) 3-21
3.10.4 Auxiliary Feedback: Pulse-and-Direction Input Option (YA[4]=0) 3-23
3.11 I/Os **3-25**
3.11.1 Digital Input 3-25
3.11.2 Digital Output 3-27
3.11.3 Analog Input 3-28
3.12 Communications **3-29**
3.12.1 RS-232 Communication 3-29
3.12.2 CANopen Communication 3-30
3.13 Powering Up **3-32**
3.14 Initializing the System **3-32**
3.15 Heat Dissipation **3-32**
3.15.1 Hornet Thermal Data 3-32
3.15.1.1 Hornet Thermal Data 3-32
3.15.1.2 Heat Dissipation Data 3-32
3.15.1.3 How to Use the Charts 3-33
3.15.2 Bee Thermal Data 3-34
3.16 Evaluation Board and Cable Kit **3-34**

Appendix: Hornet and Bee Technical Specifications A-1

A.1 Features A-1
A.1.1 Motion Control Modes A-1
A.1.2 Advanced Positioning Control Modes A-1
A.1.3 Advanced Filters and Gain Scheduling A-1
A.1.4 Fully Programmable A-1
A.1.5 Feedback Options A-1
A.1.6 Input/Output A-2
A.1.7 Built-In Protection A-2
A.1.8 Accessories A-3
A.1.9 Status Indication A-3
A.1.10 Automatic Procedures A-3
A.2 Dimensions A-3
A.2.1 Hornet A-3
A.2.2 Bee A-4
A.3 Power Ratings A-4
A.3.1 Hornet A-4
A.3.2 Bee A-5
A.4 Environmental Conditions A-5
A.4.1 Auxiliary Supply A-6
A.5 Control Specifications A-6
A.5.1 Current Loop A-6
A.5.2 Velocity Loop A-7
A.5.3 Position Loop A-7
A.6 Feedbacks A-8
A.6.1 Feedback Supply Voltage A-8
A.6.2 Main Feedback Options A-8

A.6.2.1 Incremental Encoder Input A-8
A.6.2.2 Digital Halls A-9
A.6.2.3 Interpolated Analog Encoder (Sine/Cosine) A-9
A.6.2.4 Resolver A-10
A.6.2.5 Tachometer* A-10
A.6.2.6 Potentiometer A-11
A.6.3 Auxiliary Feedback Port (output mode YA[4]= 4) A-11
A.6.4 Auxiliary Feedback Port (input mode YA[4]= 2, 0) A-12
A.7 I/Os A-12
A.7.1 Digital Input Interfaces A-12
A.7.2 Digital Output Interface A-14
A.7.3 Analog Input A-14
A.8 Communications A-15
A.9 Pulse Width Modulation (PWM) A-15
A.10 Standards Compliance A-15
A.10.1 Quality Assurance A-15
A.10.2 Design A-15
A.10.3 Safety A-16
A.10.4 EMC A-16
A.10.5 Workmanship A-16
A.10.6 PCB A-16
A.10.7 Packing A-16
A.10.8 WEEE* A-16
A.10.9 RoHS A-17

Chapter 1: Safety Information

In order to achieve the optimum, safe operation of the Hornet and Bee servo drives, it is imperative that you implement the safety procedures included in this installation guide. This information is provided to protect you and to keep your work area safe when operating the Hornet and Bee as well as the accompanying equipment.

Please read this chapter carefully before you begin the installation process.

Before you start, ensure that all system components are connected to earth ground. Electrical safety is provided through a low-resistance earth connection.

Only qualified personnel may install, adjust, maintain and repair the servo drive. A "qualified person" has the knowledge and authorization to perform tasks such as transporting, assembling, installing, commissioning and operating motors.

The Hornet and Bee servo drives contain electrostatic-sensitive components that can be damaged if handled incorrectly. To prevent any electrostatic damage, avoid contact with highly insulating materials, such as plastic film and synthetic fabrics. Place the product on a conductive surface and ground yourself in order to discharge any possible static electricity build-up.

To avoid any potential hazards that may cause severe personal injury or damage to the product during operation, keep all covers and cabinet doors shut.

The following safety symbols are used in this manual:

	Warning: This information is needed to avoid a safety hazard, which might cause bodily injury.
	Caution: This information is necessary for preventing damage to the product or to other equipment.
	Note: This is auxiliary information that ensures the correct operation of the equipment.

1.1 Warnings

	To avoid electric arcing and hazards to personnel and electrical contacts, never connect/disconnect the servo drive while the power source is on.
	Power cables can carry a high voltage, even when the motor is not in motion. Disconnect the Hornet and Bee from all voltage sources before it is opened for servicing.
	The Hornet and Bee servo drives contain grounding conduits for electric current protection. Any disruption to these conduits may cause the instrument to become hot (live) and dangerous.
	After shutting off the power and removing the power source from your equipment, wait at least 1 minute before touching or disconnecting parts of the equipment that are normally loaded with electrical charges (such as capacitors or contacts). Measuring the electrical contact points with a meter, before touching the equipment, is recommended.

1.2 Cautions

	The Hornet and Bee servo drives contain hot surfaces and electrically-charged components during operation.
	The maximum DC power supply connected to the instrument must comply with the parameters outlined in this guide.
	When connecting the Hornet and Bee to an approved 12~95 VDC auxiliary power supply, connect it through a line that is separated from hazardous live voltages using reinforced or double insulation in accordance with approved safety standards.
	Before switching on the Hornet and Bee, verify that all safety precautions have been observed and that the installation procedures in this manual have been followed.

1.3 Directives and Standards

The Hornet and Bee conform to the following industry safety standards:

Safety Standard	Item
In compliance with **MIL-STD-704**	Aircraft, Electric Power Characteristics
In compliance with **MIL-STD-810**	Environmental Engineering Considerations and Laboratory Tests
In compliance with **MIL-STD-1275**	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles
In compliance with **MIL-STD-461**	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
In compliance with **MIL-HDBK-217**	Reliability Prediction of Electronic Equipment
In compliance with **ISO-9001:2000**	Quality Management
In compliance with **UL508c**	Power Conversion Equipment
In compliance with **UL840**	Insulation Coordination, Including Clearance and Creepage Distances of Electrical Equipment
In compliance with **UL60950-1** (formerly UL1950)	Safety of Information Technology Equipment, Including Electrical Business Equipment
In compliance with **EN60204-1**	Low Voltage Directive, 73/23/EEC

The Hornet and Bee servo drives have been developed, produced, tested and documented in accordance with the relevant standards. Elmo Motion Control is not responsible for any deviation from the configuration and installation described in this documentation. Furthermore, Elmo is not responsible for the performance of new measurements or ensuring that regulatory requirements are met.

1.4 CE Mark Conformance

The Hornet and Bee servo drives are intended for incorporation in a machine or end product. The actual end product must comply with all safety aspects of the relevant requirements of the European Safety of Machinery Directive 98/37/EC as amended, and with those of the most recent versions of standards EN60204-1 and EN292-2 at the least.

According to Annex III of Article 13 of Council Directive 93/68/EEC, amending Council Directive 73/23/EEC concerning electrical equipment designed for use within certain voltage limits, the Hornet and Bee meet the provisions outlined in Council Directive 73/23/EEC. The party responsible for ensuring that the equipment meets the limits required by EMC regulations is the manufacturer of the end product.

1.5 Warranty Information

The products covered in this manual are warranted to be free of defects in material and workmanship and conform to the specifications stated either within this document or in the product catalog description. All Elmo drives are warranted for a period of 12 months from the time of installation, or 18 months from time of shipment, whichever comes first. No other warranties, expressed or implied — and including a warranty of merchantability and fitness for a particular purpose — extend beyond this warranty.

Chapter 2: Introduction

This installation guide describes the Hornet and Bee servo drives and the steps for its wiring, installation and power-up. Following these guidelines ensures maximum functionality of the drive and the system to which it is connected.

2.1 *ExtrIQ* Product Family

Elmo Motion Control's ***ExtrIQ*** product family is a set of durable motion control products for applications operating under extreme environmental conditions. The products are capable of withstanding the following extreme conditions:

Ambient Temperature Range	Non-Operating Condition	-50°C to +100°C (-58°F to 212°F)	
	Operating Condition	-40°C to +71°C (-40°F to 160°F)	
Temperature Shock	Non-Operating Condition	-40°C to +71°C (-40°F to 160°F) within 3 min.	
Altitude	Non-Operating Condition	Unlimited	
	Operating Condition	-400 to 150,000m (-1,000 to 510,000 ft)	
Relative Humidity	Non-Operating Condition	up to 95% relative humidity non-condensing at 35°C (95°F)	
	Operating Condition	up to 95% relative humidity non-condensing at 25°C (77°F), up to 90% relative humidity non-condensing at 42°C (108°F)	
Vibration	Operating Condition	20 Hz -2000 Hz, 14.6 g	
Mechanical Shock	Non-Operating Condition	±40 g	Half sine, 11 msec.
	Operating Condition	±20 g	Half sine, 11 msec.

ExtrIQ products have a high power density in the range of 10W - 9000W and current carrying capacity of up to 200A (400A peak). ***ExtrIQ*** has been tested using methods and procedures specified in a variety of extended environmental conditions (EEC) standards including:

- MIL-STD-704- Aircraft, Electric Power Characteristics
- MIL-STD-810- Environmental Engineering Considerations and Laboratory Tests
- MIL-STD-1275- Characteristics of 28 Volt DC Electrical Systems in Military Vehicles
- MIL-STD-461- Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
- MIL-HDBK-217- Reliability Prediction of Electronic Equipment

- ISO-9001:2000

Based on Elmo Motion Control's innovative ***SimplIQ*** core technology, they support a wide range of motor feedback options, programming capabilities and communication protocols.

2.2 Drive Description

The Hornet and Bee series are highly resilient digital servo drives designed to deliver "the highest density of power and intelligence". While both are light and highly compact solutions, the Bee can be used whenever reduced size and weight are essential to the application. The Hornet delivers up to**1.2 KW** of **continuous power** or **2.4 KW of peak power** in a 2 in^3 (55 X 15 x 46.5 mm or 2" x 0.6" x 1.8") 38cc package. The Bee delivers up to **¼ KW** of **continuous power** or **½ KW of peak power**.

Designed for OEMs, the Hornet and Bee are part of the Elmo's ***ExtrIQ*** product line designed to endure extended environmental operating conditions. The digital drives are based on Elmo's advanced ***SimplIQ*** motion control technology. They operate from a DC power source in current, velocity, position and advanced position modes, in conjunction with a permanent-magnet synchronous brushless motor, DC brush motor, linear motor or voice coil. They are designed for use with any type of sinusoidal and trapezoidal commutation, with vector control. The Hornet and Bee can operate as a stand-alone device or as part of a multi-axis system in a distributed configuration on a real-time network.

The drives are easily set up and tuned using Elmo's *Composer* software tools. This Windows-based application enables users to quickly and simply configure the servo drive for optimal use with their motor. The Hornet and Bee, as part of the *SimplIQ* product line, are fully programmable with Elmo *Metronome* motion control language.

Power to the drives is provided by a 12 ~ 95 VDC isolated DC power source (not included with the Hornet and Bee). A "smart" control-supply algorithm enables the Hornet and Bee to operate with only one power supply with no need for an auxiliary power supply for the logic.

If back-up functionality is required for storing control parameters in case of power-loss, an external 12 ~ 95 VDC isolated supply should be connected (via the +VL terminal on the Hornet and Bee) providing maximum flexibility and backup functionality when needed.

Note: This back-up functionality can operate from any voltage source within the 12 ~ 95 VDC range. This is much more flexible than to be restricted by only using a standard 24VDC power supply.

If back-up power is not needed, two terminals (VP and VL) are shorted so that the main power supply will also power the control/logic supply. In this way there is no need for a separate control/logic supply.

The Hornet and Bee are PCB mounted devices which enable efficient and cost saving implementation.

2.3 Product Features

2.3.1 Current Control

- Fully digital
- Sinusoidal commutation with vector control or trapezoidal commutation with encoder and/or digital Hall sensors
- 12-bit current loop resolution
- Automatic gain scheduling, to compensate for variations in the DC bus power supply

2.3.2 Velocity Control

- Fully digital
- Programmable PI and FFW (feed forward) control filters
- Sample rate two times current loop sample time
- "On-the-fly" gain scheduling
- Automatic, manual and advanced manual tuning and determination of optimal gain and phase margins

2.3.3 Position Control

- Programmable PIP control filter
- Programmable notch and low-pass filters
- Position follower mode for monitoring the motion of the slave axis relative to a master axis, via an auxiliary encoder input
- Pulse-and-direction inputs
- Sample rate four times current loop sample time
- Fast event capturing inputs
- PT and PVT motion modes
- Position-based and time-based ECAM mode that supports a non-linear follower mode, in which the motor tracks the master motion using an ECAM table stored in flash memory
- Dual (position/velocity) loop
- Fast output compare (OC)

2.3.4 Communication Options

Hornet and Bee users can use two communication options:

- RS-232 serial communication
- CANopen for fast communication in a multi-axis distributed environment

2.3.5 Feedback Options

- Incremental Encoder – up to 20 Mega-Counts (5 Mega-Pulse) per second
- Digital Halls – up to 2 KHz
- Incremental Encoder with Digital Halls for commutation – up to 20 Mega-Counts per second for encoder
- Interpolated Analog Sine/Cosine Encoder – up to 250 KHz (analog signal)
  Internal Interpolation - up to x4096

Automatic Correction of amplitude mismatch, phase mismatch, signals offset
Auxiliary emulated, unbuffered, single-ended, encoder output

- Resolver
  Programmable 10~15 bit resolution
  Up to 512 Revolution Per Second (RPS)
  Auxiliary emulated, unbuffered, single-ended, encoder output
- Tachometer, Potentiometer
- Elmo drives provide supply voltage for all the feedback options

2.3.6 Fault Protection

The Hornet and Bee include built-in protection against possible fault conditions, including:

- Software error handling
- Status reporting for a large number of possible fault conditions
- Protection against conditions such as excessive temperature, under/over voltage, loss of commutation signal, short circuits between the motor power outputs and between each output and power input return
- Recovery from loss of commutation signals and from communication errors

2.4 System Architecture

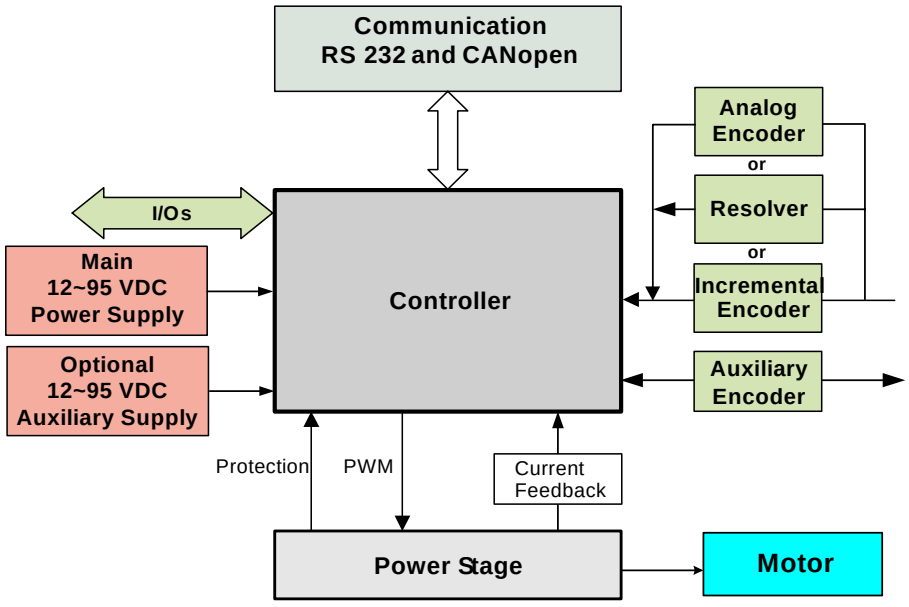


Figure 2-1 Hornet/Bee System Block Diagram

2.5 How to Use this Guide

In order to install and operate your Elmo Hornet or Bee servo drives, you will use this manual in conjunction with a set of Elmo documentation. Installation is your first step; after carefully reading the safety instructions in the first chapter, the following chapters provide you with installation instructions as follows:

Chapter 3, *Installation*, provides step-by-step instructions for unpacking, mounting, connecting and powering up the Hornet and Bee.

The Appendix, *Technical Specifications*, lists all the drive ratings and specifications.

Upon completing the instructions in this guide, your Hornet and Bee servo drives should be successfully mounted and installed. From this stage, you need to consult higher-level Elmo documentation in order to set up and fine-tune the system for optimal operation. The following figure describes the accompanying documentation that you will require.

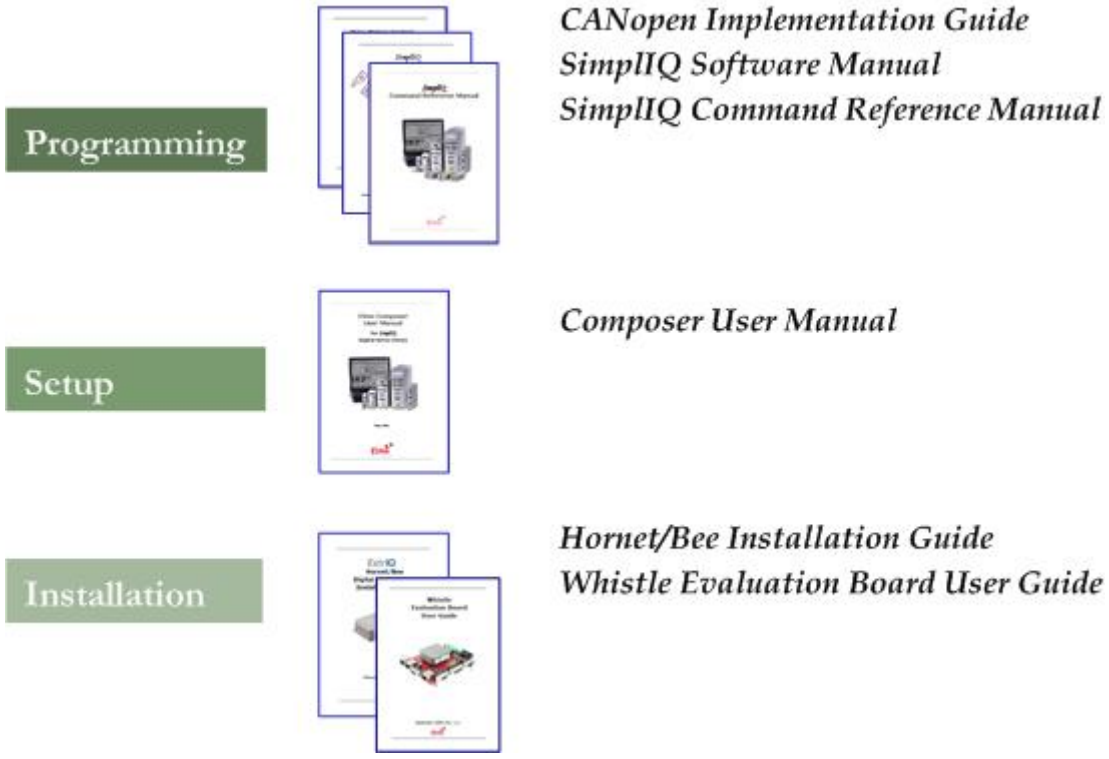


Figure 2-2: **Elmo Digital Servo Drive Documentation Hierarchy**

As depicted in the previous figure, this installation guide is an integral part of the Hornet and Bee documentation set, comprising:

- The Composer *Software Manual*, which includes explanations of all the software tools that are part of Elmo's Composer software environment.
- The *SimplIQ Command Reference Manual*, which describes, in detail, each software command used to manipulate the Hornet and Bee motion controller.
- The *SimplIQ Software Manual*, which describes the comprehensive software used with the Hornet and Bee.

Chapter 3: Installation

3.1 Site Requirements

You can guarantee the safe operation of the Hornet and Bee by ensuring that they are installed in an appropriate environment.

Feature	Value
Ambient operating temperature	-40°C to +71°C (-40°F to 160°F)
Maximum relative humidity	95% non-condensing
Operating area atmosphere	No flammable gases or vapors permitted in area

The Hornet and Bee dissipate heat by convection. The maximum operating ambient temperature of -40°C to +71°C (-40°F to 160°F) must not be exceeded.

3.2 Unpacking the Drives

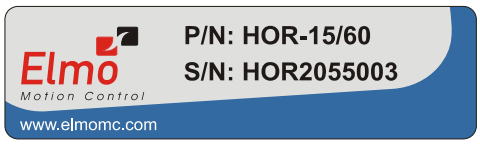
Before you begin working with the Hornet or Bee, verify that you have all of their components, as follows:

- The Hornet or Bee servo drives
- The Composer software and software manual

The Hornet and Bee are shipped in a cardboard box with styrofoam protection.

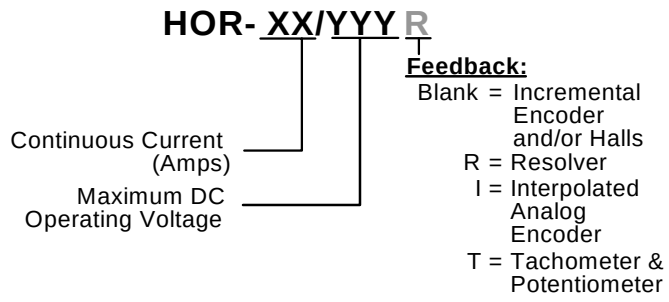
To unpack the Hornet and Bee:

1. Carefully remove the servo drive from the box and the Styrofoam.
2. Check the drive to ensure that there is no visible damage to the instrument. If any damage has occurred, report it immediately to the carrier that delivered your drive.
3. To ensure that the Hornet or Bee you have unpacked is the appropriate type for your requirements, locate the part number sticker on the side of the Hornet or and Bee. It looks like this:



HOR001A

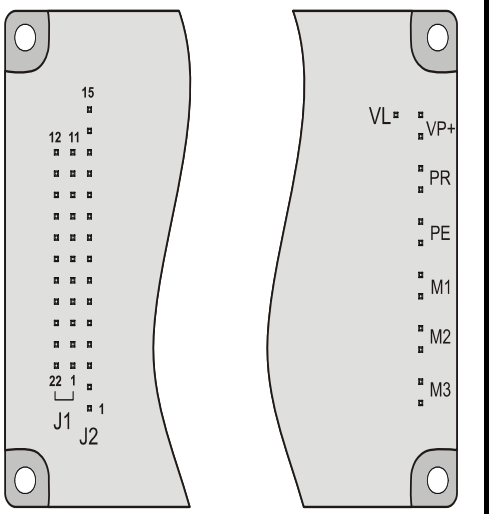
The part number at the top gives the type designation as follows:



Verify that the Hornet or Bee type is the one that you ordered, and ensure that the voltage meets your specific requirements.

3.3 Pinouts

3.3.1 Connector Types

No. Pins	Type	Port	Function	Connector Location
2x11	2 mm Pitch 0.51 mm SQ	J1	I/O, COMM, Auxiliary Feedback	
15		J2	Main Feedback, Analog Input, LED	
2		M1	Motor power output 1	
2		M2	Motor power output 2	
2		M3	Motor power output 3	
2		PE	Protective earth	
2		PR	Power input return	
2		VP+	Positive power input	
1		VL	Auxiliary power input	

3.3.2 Connector J1

Pin	Signal	Function
J1/1	RS232_RX	RS232 receive
J1/2	RS232_TX	RS232 Transmit
J1/3	RS232_COMRET	Communication return
J1/4	SUPRET	Supply return
J1/5	AUX PORT CHA	AUX PORT CHA (bidirectional)
J1/6	SUPRET	Supply return
J1/7	OUT1	Programmable Digital output 1
J1/8	OUT2	Programmable Digital output 2
J1/9	IN1	Programmable Digital input 1
J1/10	IN2	Programmable Digital input 2
J1/11	IN3	Programmable Digital input 3
J1/12	IN4	Programmable Digital input 4
J1/13	IN5	Programmable Digital input 5
J1/14	IN6	Programmable Digital input 6
J1/15	INRET	Programmable Digital input return
J1/16	OUTRET2	Programmable Digital output 2 return
J1/17	OUTRET1	Programmable Digital output 1 return
J1/18	AUX PORT CHB	AUX PORT CHB (bidirectional)
J1/19	AUX PORT INDEX	AUX PORT INDEX (bidirectional)
J1/20	CAN_COMRET	Communication return
J1/21	CAN_L	CAN_L busline (dominant low)
J1/22	CAN_H	CAN_H busline (dominant high)

3.3.3 Connector J2

Pin	Signal	Function
J2/1	+5V	Encoder/Hall +5V supply voltage. Maximum output current: 200mA.
J2/2	SUPRET	Supply return
J2/3	ANALIN1+	Analog input 1+
J2/4	ANALIN1-	Analog input 1-
J2/5	CHA	Channel A input
J2/6	CHA-	Channel A input complement
J2/7	CHB	Channel B input
J2/8	CHB-	Channel B input complement
J2/9	INDEX+	Index input
J2/10	INDEX-	Index input complement
J2/11	HA	Hall sensor A input
J2/12	HB	Hall sensor B input
J2/13	HC	Hall sensor C input
J2/14	LED_2_OUT	Bi-color indication output 2 (Cathode)
J2/15	LED_1_OUT	Bi-color indication output 1 (Anode)

3.4 Mounting

3.4.1 Hornet

The Hornet was designed for mounting on a printed circuit board (PCB). It is connected by 2mm pitch 0.51 mm square pins. When designing the Hornet into a device, be sure to leave about 1 cm (0.4") outward from the heatsink to enable free air convection around the Hornet. We recommend that the Hornet be soldered directly to the board. Alternatively, the Hornet can be attached to socket connectors mounted on the PCB. If the PCB is enclosed in a metal chassis, we recommend that the Hornet be screw-mounted to it as well to help with heat dissipation. The Hornet has screw-mount holes on each corner of the heatsink for this purpose.

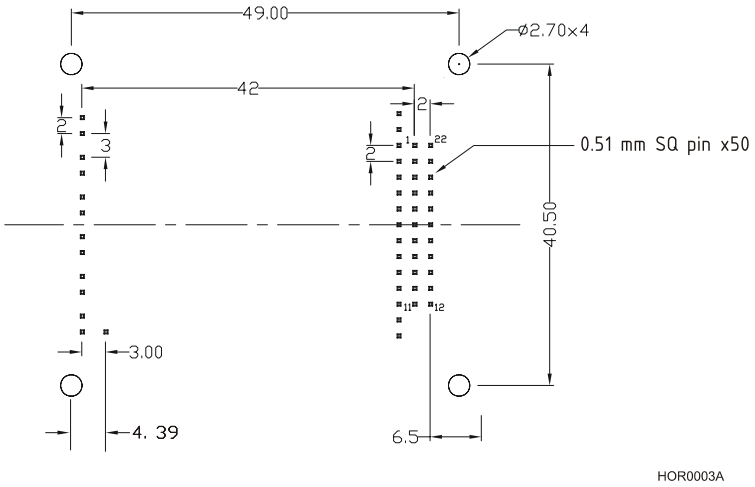
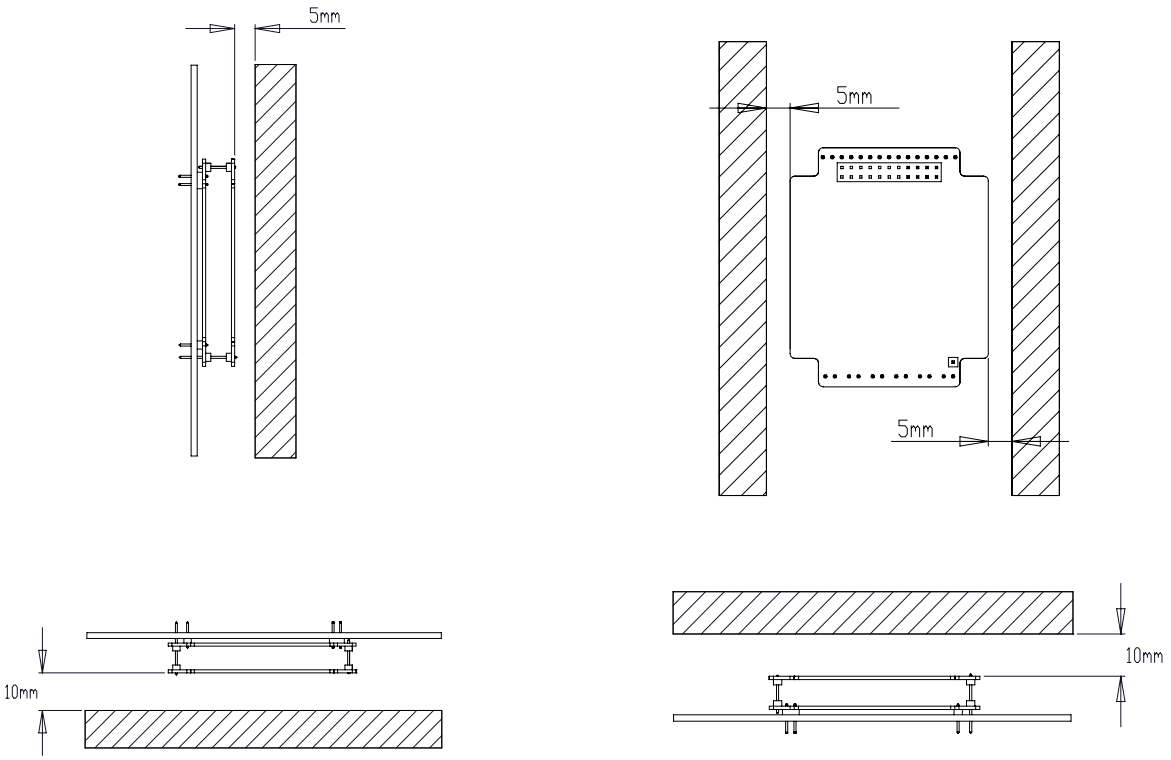


Figure 3-1: Hornet Footprint

3.4.2 Bee

The Bee was designed for mounting on a printed circuit board (PCB). It is connected by 2mm pitch 0.51 mm square pins. When designing the Bee into a device, be sure to leave about 1 cm (0.4") outward from the lower board to enable free air convection around the Bee. We recommend that the Bee be soldered directly to the board. Alternatively, the Bee can be attached to socket connectors mounted on the PCB.

Note: Elmo recommends you leave approximately 1 cm (.4 in) of space on the side opposite the terminals to allow for free air convection.



3.5 Integrating the Hornet or Bee on a PCB

The Hornet and Bee are designed to be mounted on a PCB, either by soldering its pins directly to the PCB or by using suitable socket connectors. In both cases the following rules apply:

3.5.1 Traces

1. The **size of the traces** on the PCB (thickness and width) is determined by the current carrying capacity required by the application.
   - The rated continuous current limit (Ic) of the Hornet and Bee is the current used for sizing the motor traces (M1, M2, M3 and PE) and power traces (VP+, PR and PE).
   - For control, feedbacks and Inputs/ outputs conductors the actual current is very small but "generous" thickness and width of the conductors will contribute to a better performance and lower interferences.
2. The **traces should be as short as possible** to minimize EMI and to minimize the heat generated by the conductors.
3. The **spacing** between the high voltage conductors (VP+, PR, M1, M2, M3, VL) must be at least:
   - Surface layer: 1.5 mm
   - Internal layer: 0.10 mm

Complying with the rules above will help satisfy UL safety standards, MIL-STD-275 and the IPC-D-275 standard for non-coated conductors, operating at voltages lower than 100VDC and at "unlimited altitudes" (above 10,000 meters – 30,000 feet).

3.5.2 Grounds and Returns

The "Returns" of the Hornet and Bee are structured internally in a star configuration. The returns in each functional block are listed below:

Functional Block	**Return Pin**
Power	PR (Power Return)
Internal Switch Mode P.S.	PR (Power Return)
RS232 Communications	RS232_COMRET (J1/3)
CAN Communications	CAN_COMRET (J1/20)
Control section	Internal, not accessible
Main Feedback	SUPRET (J2/2)
Aux. Feedback	SUPRET (J1/4)
Analog input	ANLRET (J2/2)

The returns above are all shorted within the Hornet and Bee in a topology that results in optimum performance.

1. When wiring the traces of the above functions, on the Integration Board, the **Returns** of each function must be **wired separately** to its designated terminal on the Hornet or Bee. **DO NOT USE A COMMON GROUND PLANE**. Shorting the commons on the Integration Board may cause performance degradation (ground loops, etc).

2. **Inputs**: The 6 inputs are optically isolated from the other parts of the Hornet and Bee. All 6 inputs share a single common "Return" (INRET - J1/15). To retain isolation, the Input Return pin, as well as other conductors on the input circuit, must be laid out separately.

3. **Outputs**: The 2 outputs are optically isolated from the other parts of the Hornet and Bee. Each output has a separate floating return (OUTRET1 - J1/17 for output 1 and OUTRET2 J1/16 for output 2). To retain isolation, the Output Return pins, as well as other conductors on the output circuit, must laid out separately.

4. **Return Traces:** The return traces should be as large as possible, but without shorting each other, and with minimal cross-overs.

5. **Main Power Supply and Motor Traces:** The power traces must be kept as far away as possible from the feedback, control and communication traces.

6. **PE Terminal**: The PE terminal is connected directly to the Hornet's heatsink or to the Bee's 2 PE strips on its lower board. In the Hornet, the heatsink serves as an EMI common plane. The PE terminal should be connected to the system's Protective Earth. Any other metallic parts (such as the chassis) of the assembly should be connected to the Protective Earth as well.

7. Under normal operating conditions, the PE trace carries no current. The only time these traces carry current is under abnormal conditions (such as when the device has become a potential shock or fire hazard while conducting external EMI interferences directly to ground). When connected properly the PE trace prevents these hazards from affecting the drive.

Follow these instructions to ensure safe and proper implementation. Failure to meet any of the above-mentioned requirements can result in drive/controller/host failure.

3.6 The Hornet/Bee Connection Diagram

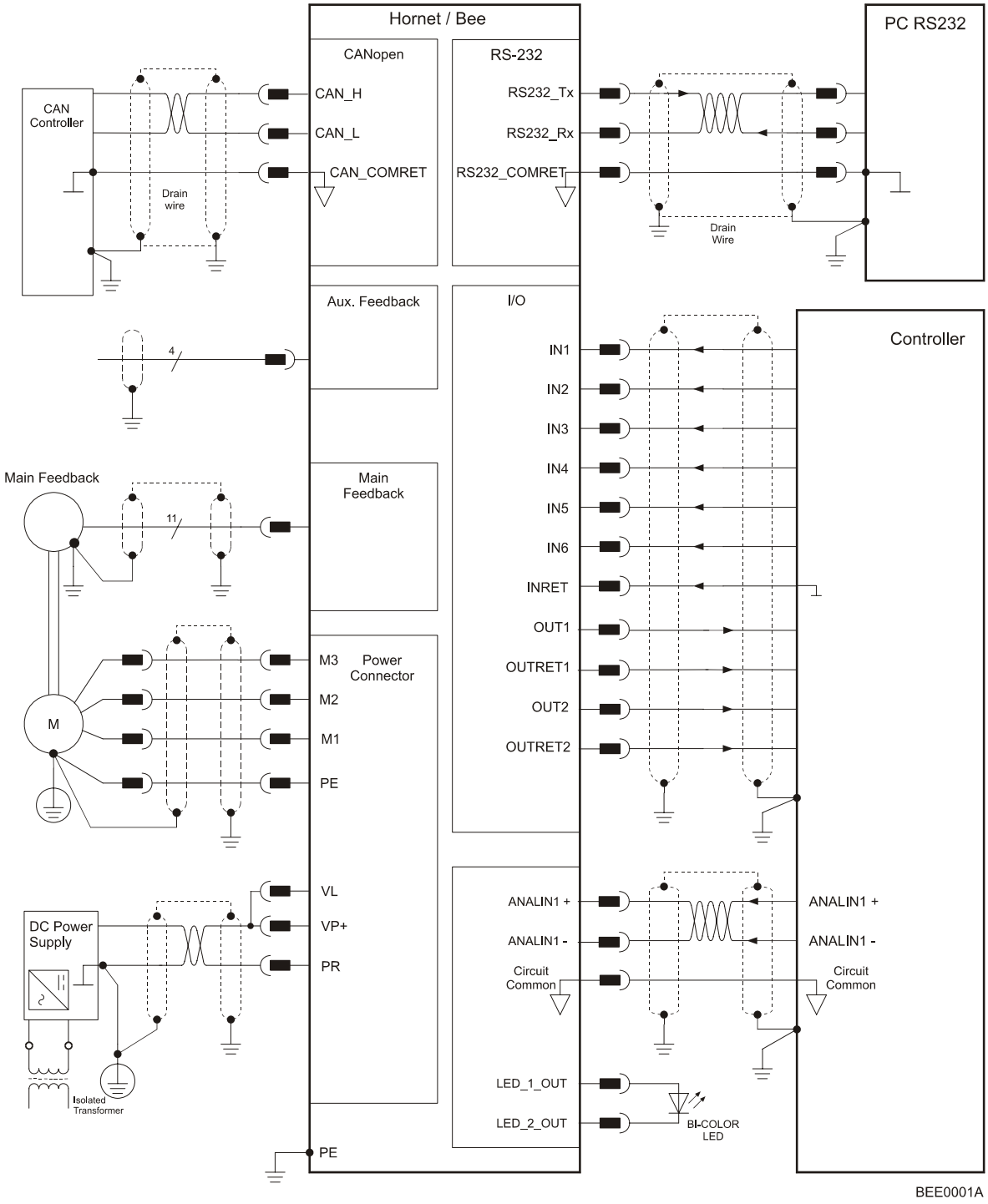


Figure 3-2: Hornet/Bee Connection Diagram

3.7 Main Power and Motor Power

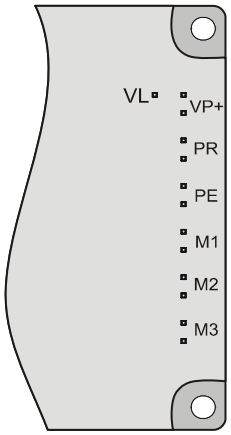
Pin	Function	Cable		Pin Positions
VP+	Pos. Power input	Power		
PR	Power return	Power		
PE	Protective earth	Power		
		AC Motor	**DC Motor**	
PE	Protective earth	Motor	Motor	
M1	Motor phase	Motor	N/C	
M2	Motor phase	Motor	Motor	
M3	Motor phase	Motor	Motor	
	When connecting several drives to several motors, all should be wired in the same motor phases and feedback sequences. This will enable the same ***SimplIQ*** program to run on all drives.			

Table 3-1: ***Connector for Main Power and Motor***

3.7.1 Connecting Motor Power

Connect the M1, M2, M3 and PE pins on the Hornet and Bee in the manner described in section 3.5 (Integrating the Hornet and Bee on a PCB). The phase connection is arbitrary as the Composer will establish the proper commutation automatically during setup. However, if you plan to copy the setup to other drives, then the phase order on all copy drives must be the same.

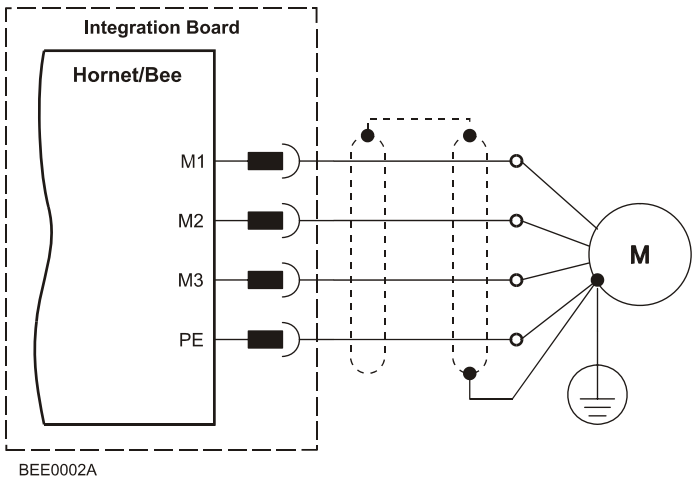


Figure 3-3: AC ***Motor Power Connection Diagram***

3.7.2 Connecting Main Power

Connect the VP+, PR and PE pins on the Hornet and Bee in the manner described in section 3.5 (Integrating the Hornet and Bee on a PCB).

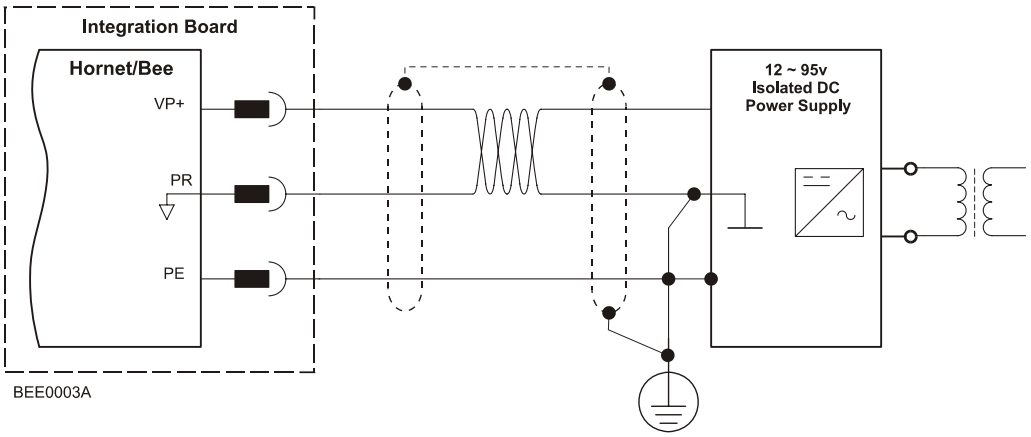
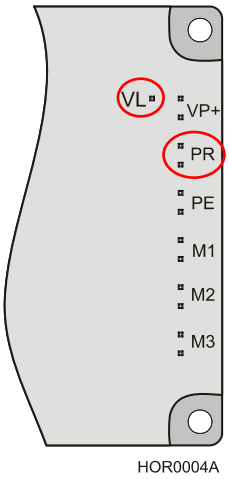


Figure 3-4: ***Main Power Supply Connection Diagram***

3.8 Auxiliary Supply (for drive logic)

Notes for 12 ~ 95 VDC auxiliary supply connections:

Connect the VL and PR pins on the Hornet and Bee in the manner described in section 3.5 (Integrating the Hornetand Bee on a PCB).

Pin	Function	Pin Positions
VL	Auxiliary Supply Input	
PR	Supply Input Return	

	Caution: Power from the Hornet and Bee to the motor must come from the Main Supply and **NOT** from the Auxiliary Supply.

Table 3-2: ***Auxiliary Supply Pins***

3.8.1 Single Supply

A single isolated DC power supply can provide power for both the main power and the Auxiliary (Drive Logic) Supply. The drawing below shows how a single supply is connected.

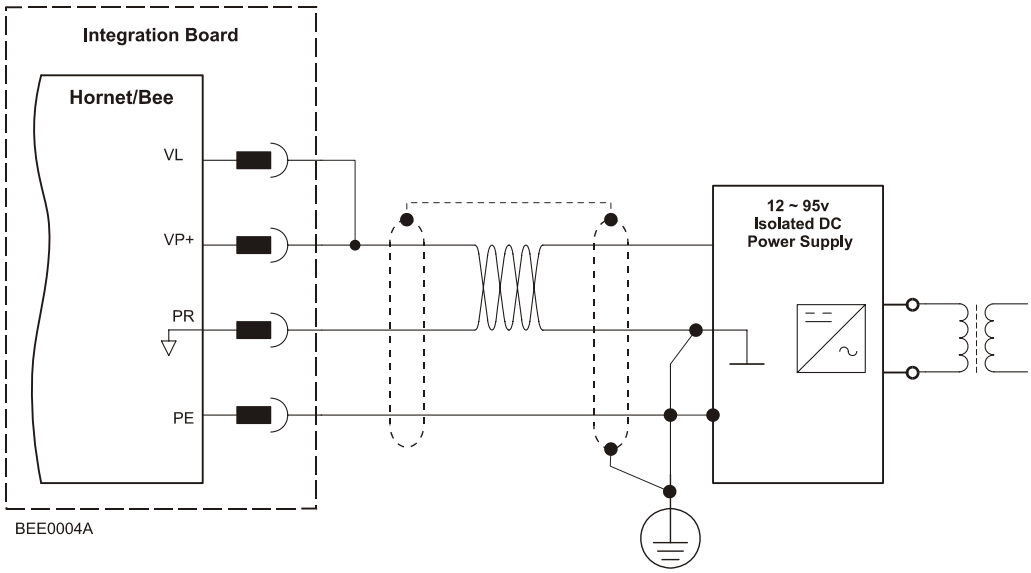


Figure 3-5: ***Single Supply for both the Main Power Supply and the Auxiliary Supply***

3.8.2 Separate Auxiliary Supply

Power to the Auxiliary Supply can be provided by a separate Auxiliary Supply.

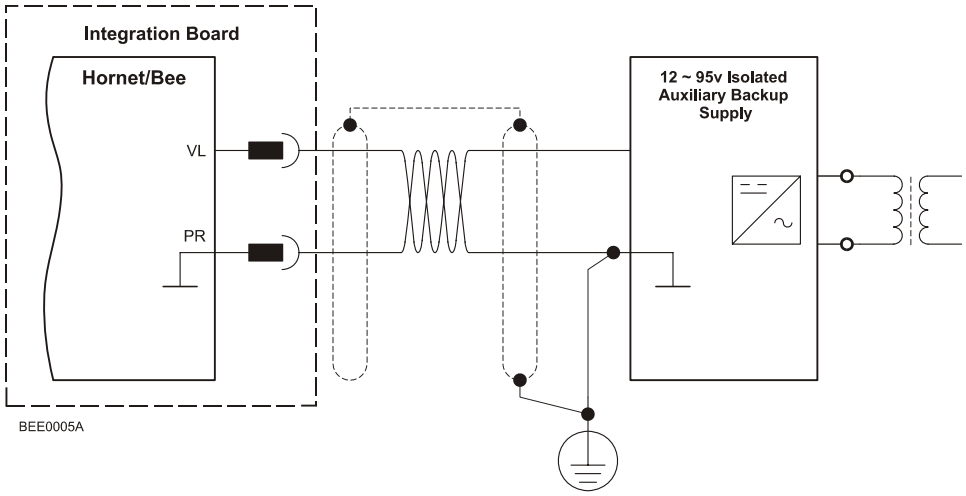


Figure 3-6: ***Separate Auxiliary Supply Connection Diagram***

3.8.3 Shared Supply

A "Main" DC Power Supply can be designed to supply power to the drive's Logic as well as to the Main Power (see Figure 3-5). If backup functionality is required (for storing control parameters in case of power-outs) an additional backup supply can be connected by implementing 'diode coupling' (see the Aux. Backup Supply in Figure 3-7).

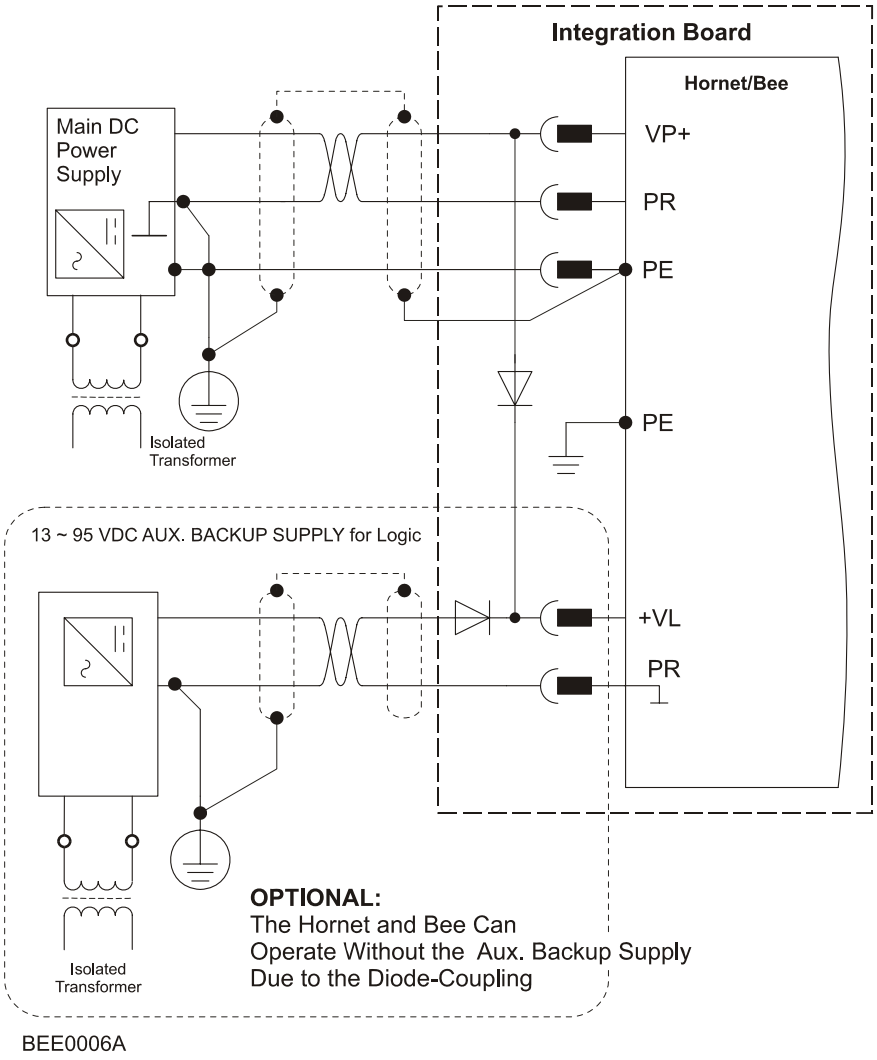


Figure 3-7: ***Shared Supply Connection Diagram***

3.9 Main Feedback

The Main Feedback port is used to transfer feedback data from the motor to the drive. In order to copy the setup to other drives, the phase order on all copy drives must be the same.

The Hornet and Bee can accept any one the following devices as a main feedback mechanism:

- Incremental encoder only
- Incremental encoder with digital Hall sensors
- Digital Hall sensors only
- Incremental Analog (Sine/Cosine) encoder (option)
- Resolver (option)
- Tachometer (option)
- Potentiometer (option)

	Incremental Encoder		**Interpolated Analog Encoder**		**Resolver**		**Tachometer and Potentiometer**	
	HOR XX/YYY_, BEE XX/YYY_		HOR XX/YYY**I**, BEE XX/YYY**I**		HOR XX/YYY**R**, BEE XX/YYY**R**		HOR XX/YYY**T**, BEE XX/YYY**T**	
Pin	**Signal**	**Function**	**Signal**	**Function**	**Signal**	**Function**	**Signal**	**Function**
J2/13	HC	Hall sensor C input	HC	Hall sensor C input	NC	-	HC	Hall sensor C input
J2/11	HA	Hall sensor A input	HA	Hall sensor A input	NC	-	HA	Hall sensor A input
J2/2	SUPRET	Supply return	SUPRET	Supply return	SUPRET	Supply return	SUPRET	Supply return
J2/1	+5V	Encoder/Hall +5V supply	+5V	Encoder/Hall +5V supply	+5V	Encoder/Hall +5V supply	+5V	Encoder/Hall +5V supply
J2/6	CHA-	Channel A complement	A-	Sine A complement	S3	Sine A complement	Tac 1-	Tacho Input 1 Neg. (20V max)
J2/5	CHA	Channel A	A+	Sine A	S1	Sine A	Tac 1+	Tacho Input 1 Pos. (20V max)
J2/10	INDEX-	Index complement	R-	Reference complement	R2	Vref complmnt f= 1/TS, 50mA Maximum	NC	-
J2/9	INDEX	Index	R+	Reference	R1	Vref f=1/TS, 50mA Max.	POT	Potentiometer Input (5V Max)
J2/12	HB	Hall sensor B input	HB	Hall sensor B input	NC	-	HB	Hall sensor B input
J2/8	CHB-	Channel B complement	B-	Cosine B complement	S4	Cosine B complement	Tac 2-	Tacho Input 2 Neg. (50V max)
J2/7	CHB	Channel B	B+	Cosine B	S2	Cosine B	Tac 2+	Tacho Input 2 Pos. (50V max)
J2/3	ANALIN+ is used for Analog Input							
J2/4	ANALIN- is used for Analog Input							
J2/14	LED_2_OUT (AOKLED cathode) is used for LED indication							
J2/15	LED_1_OUT (AOKLED anode) is used for LED indication							

Table 3-3: Main Feedback Pin Assignments

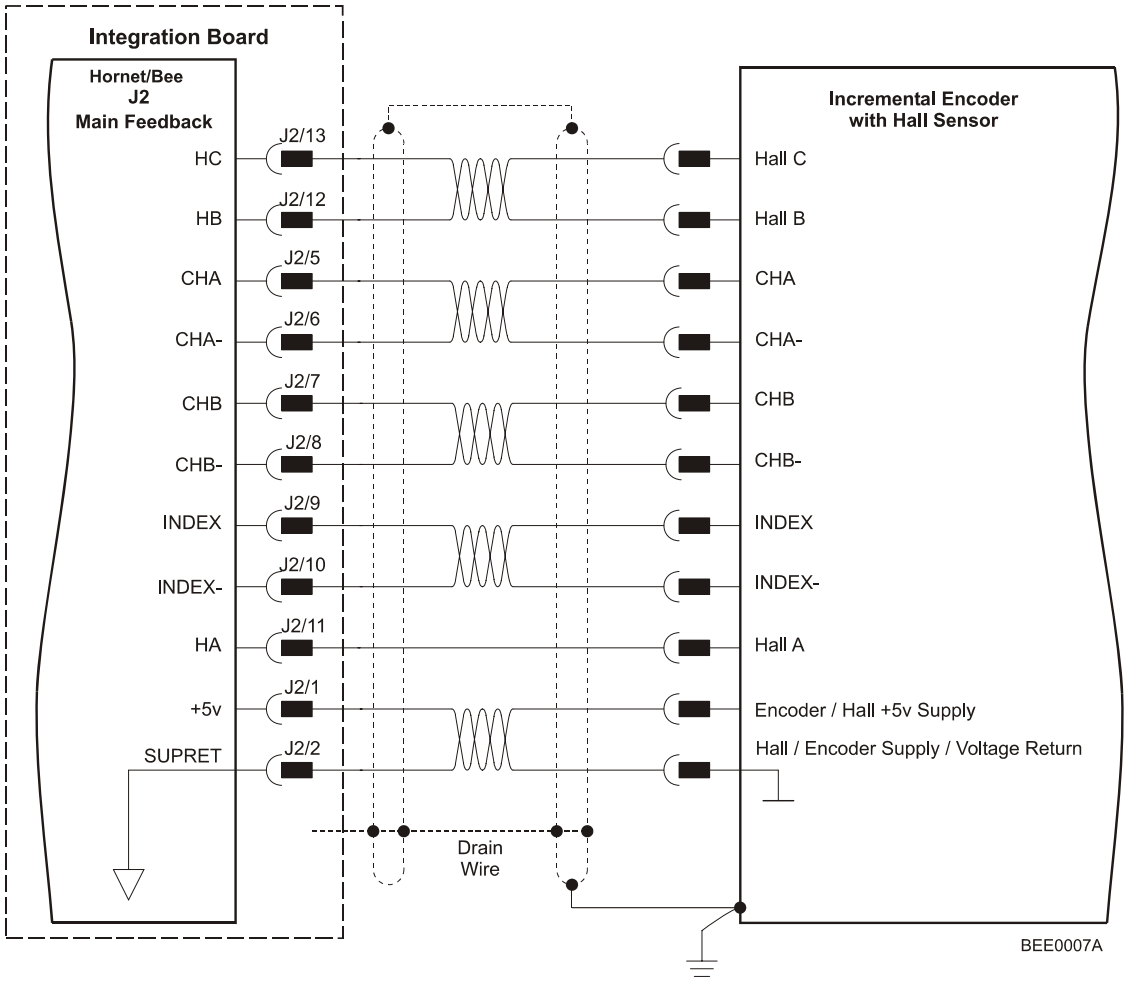


Figure 3-8: Main Feedback- Incremental Encoder Connection Diagram

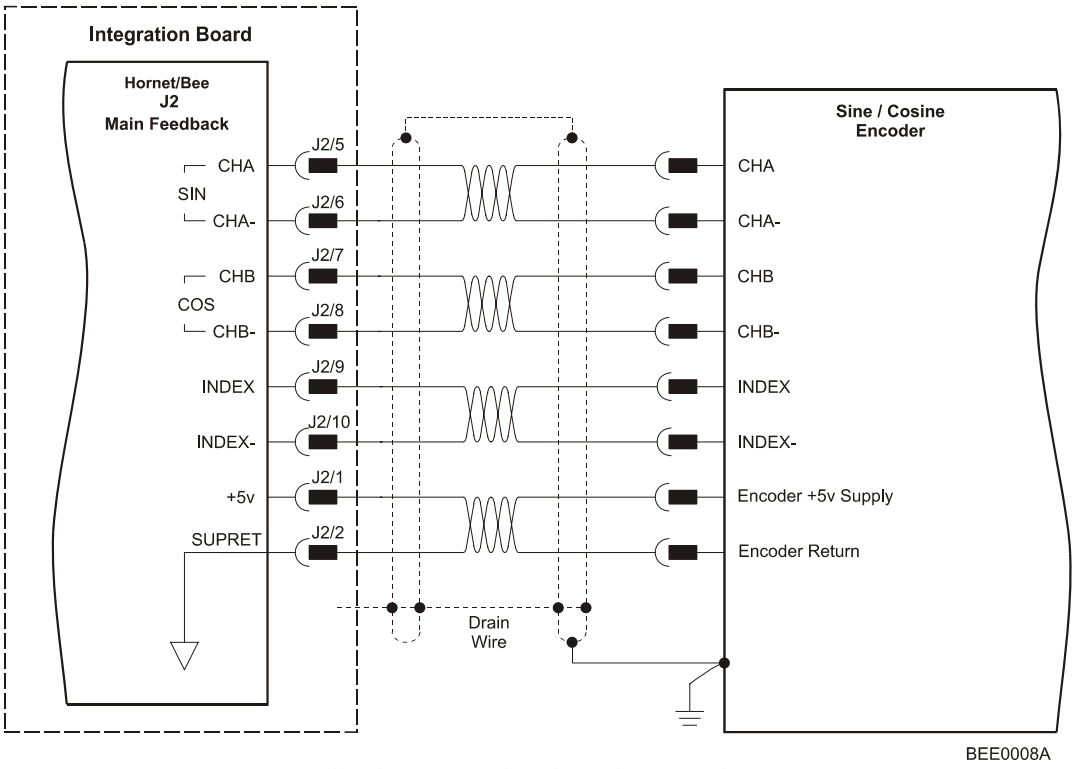


Figure 3-9: Main Feedback – Interpolated Analog Encoder Connection Diagram

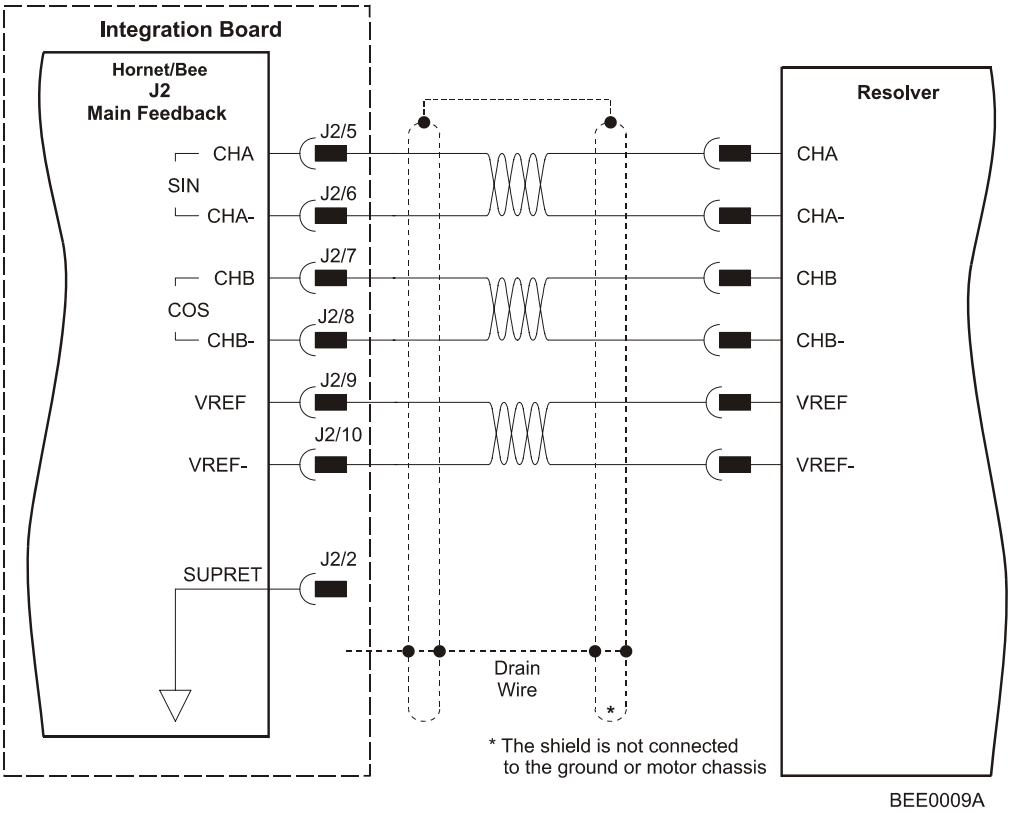


Figure 3-10: Main Feedback – Resolver Connection Diagram

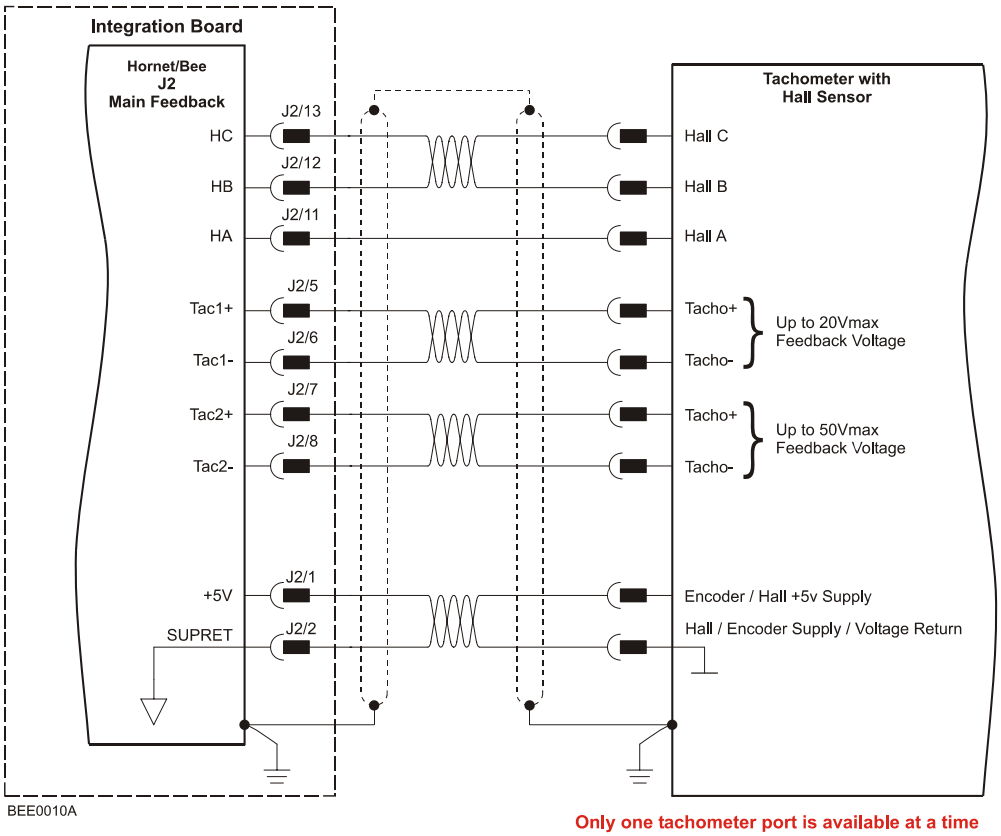


Figure 3-11: Main Feedback – Tachometer Feedback with Digital Hall Sensor Connection Diagram for Brushless Motors

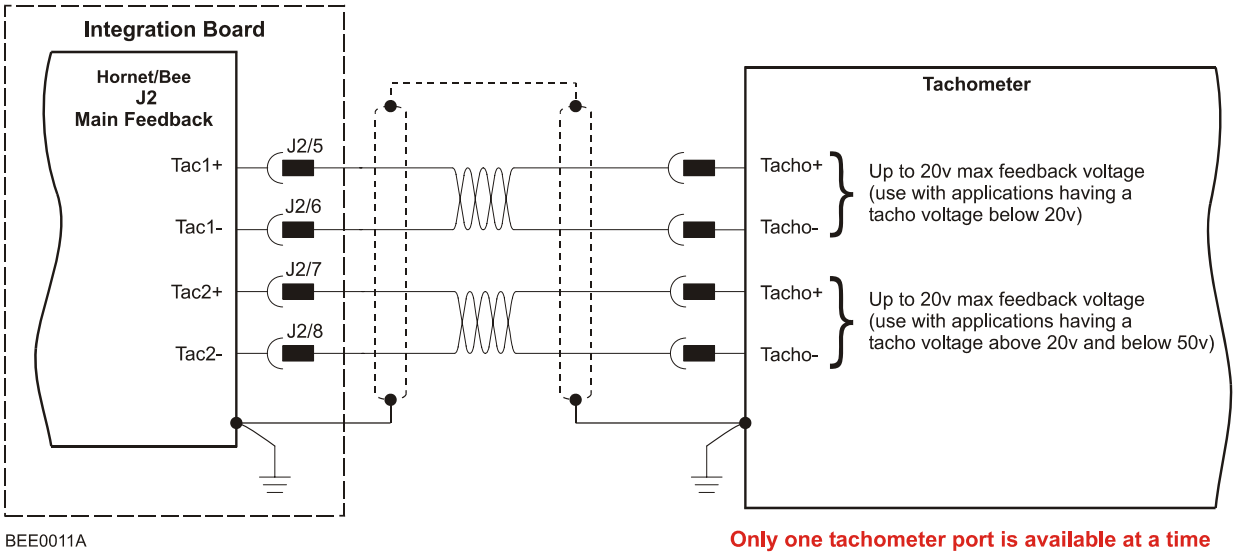


Figure 3-12: ***Main Feedback – Tachometer Feedback Connection Diagram for Brush Motors***

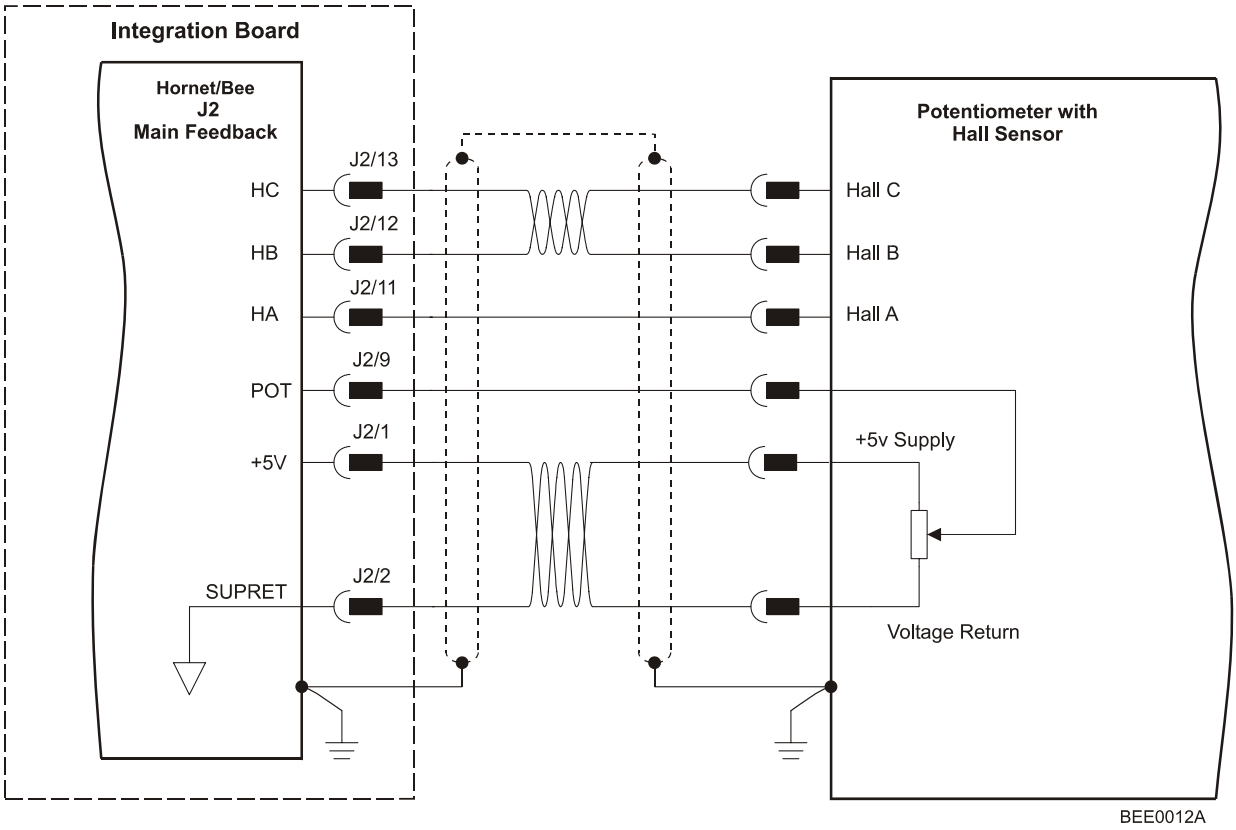


Figure 3-13: ***Main Feedback – Potentiometer Feedback with Digital Hall Sensor Connection Diagram for Brushless Motors***

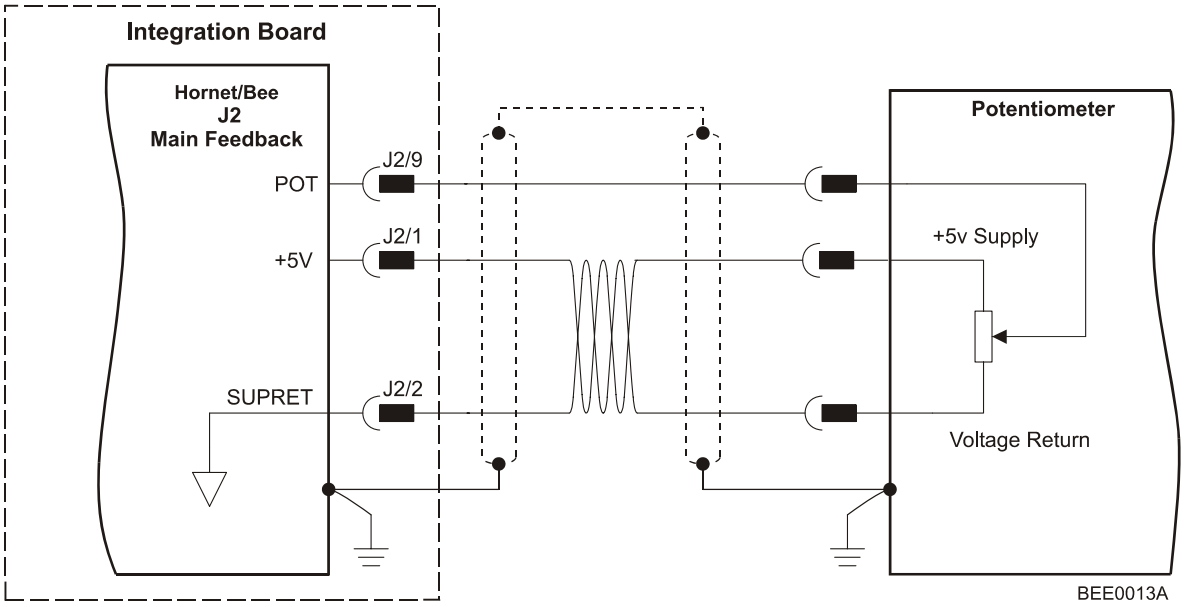


Figure 3-14: ***Main Feedback – Potentiometer Feedback Connection Diagram for Brush Motors and Voice Coils***

3.10 Auxiliary Feedback

For auxiliary feedback, select one of the following options:

a. **Single-ended emulated encoder outputs**, used to provide emulated encoder signals to another controller or drive. The Emulated Encoder Output Option is only available when using a Resolver or Analog Encoder as the main feedback device.

   This option can be used when:

   - The Hornet and Bee are used as current amplifiers to provide position data to the position controller.
   - The Hornet and Bee are used in velocity mode to provide position data to the position controller.
   - The Hornet and Bee are used as masters in follower or ECAM mode.

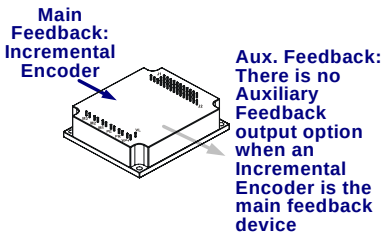
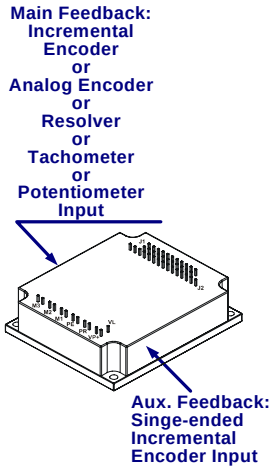
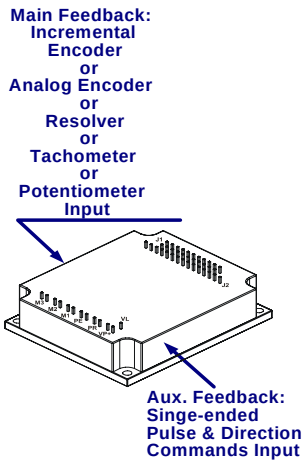
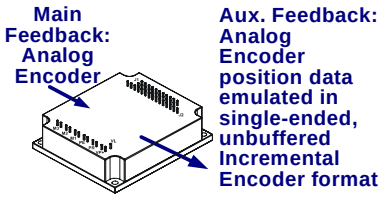
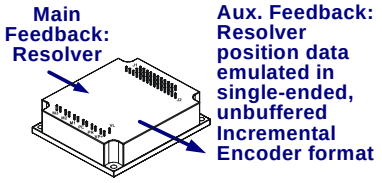
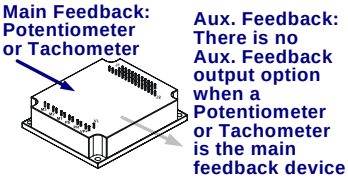
b. **Single-ended auxiliary encoder input**, for the input of position data of the master encoder in follower or ECAM mode.

c. **Pulse-and-direction input**, for single-ended input of pulse-and-direction position commands.

When using one of the auxiliary feedback options, the relevant functionality is software selected for that option. Refer to the *SimplIQ Command Reference Manual* for detailed setup information.

3.10.1 Main and Auxiliary Feedback Combinations

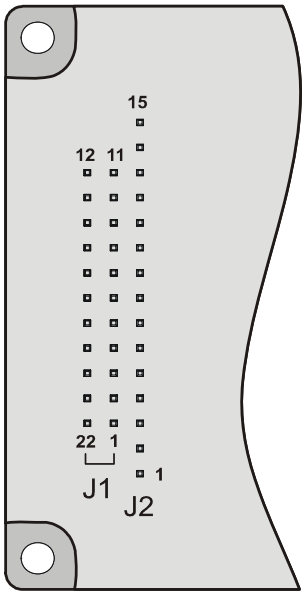
The Main Feedback is always used in motion control devices whereas Auxiliary Feedback is often, but not always used. The Auxiliary Feedback connector on the Hornet and Bee has three bi-directional pins (CHA, CHB and INDEX). When used in combination with Main Feedback, the Auxiliary Feedback can be set, by software, as follows:

<table>
<tr><th rowspan="2">SW Setting
Main Feedback</th><th colspan="3">Auxiliary Feedback</th></tr>
<tr><th>YA[4] = 4
(Aux. Feedback: output)</th><th>YA[4] = 2
(Aux. Feedback: input)</th><th>YA[4] = 0
(Aux. Feedback: input)</th></tr>
<tr><td>Incremental Encoder Input</td><td>★
 
</td><td rowspan="3"> 
</td><td rowspan="3"> 
</td></tr>
<tr><td>Interpolated Analog (Sin/Cos) Encoder Input</td><td>★
 
</td></tr>
<tr><td>Resolver Input</td><td>✸
 
</td></tr>
<tr><td>Potentiometer Tachometer Input</td><td> 
</td></tr>
<tr><td>Typical Applications</td><td>★ Any application where the main encoder is used, not only for the drive, but also for other purposes such as position controllers and/or other drives.
★ Analog Encoder applications where position data is required in the Encoder's quadrature format.
✸ Resolver applications where position data is required in the Encoder's quadrature format.</td><td>Any application where two feedbacks are used by the drive.
The Auxilliary Feedback port serves as an input for the auxiliary incremental encoder.
For applications such as Follower, ECAM, or Dual Loop.</td><td>Any application where two feedbacks are used by the drive.
The Auxilliary Feedback port serves as an input for Pulse & Direction Commands.</td></tr>
</table>

3.10.2 Auxiliary Feedback: Emulated Encoder Output Option (YA[4]=4)

Pin	Signal	Function
J1/4	SUPRET	Supply return
J1/19	INDEX+	Index output
J1/18	CHBO	Channel B output
J1/5	CHAO	Channel A output

Pin Position



Note: The Emulated Encoder Output Option is only available when using a Resolver or Analog Encoder as the main feedback device.

Note: The Hornet and Bee's Auxiliary Feedback is single-ended. When mounted on an integration board, circuitry can be added to make it differential.

Table 3-4: Emulated Single-Ended Encoder Output Pin Assignments

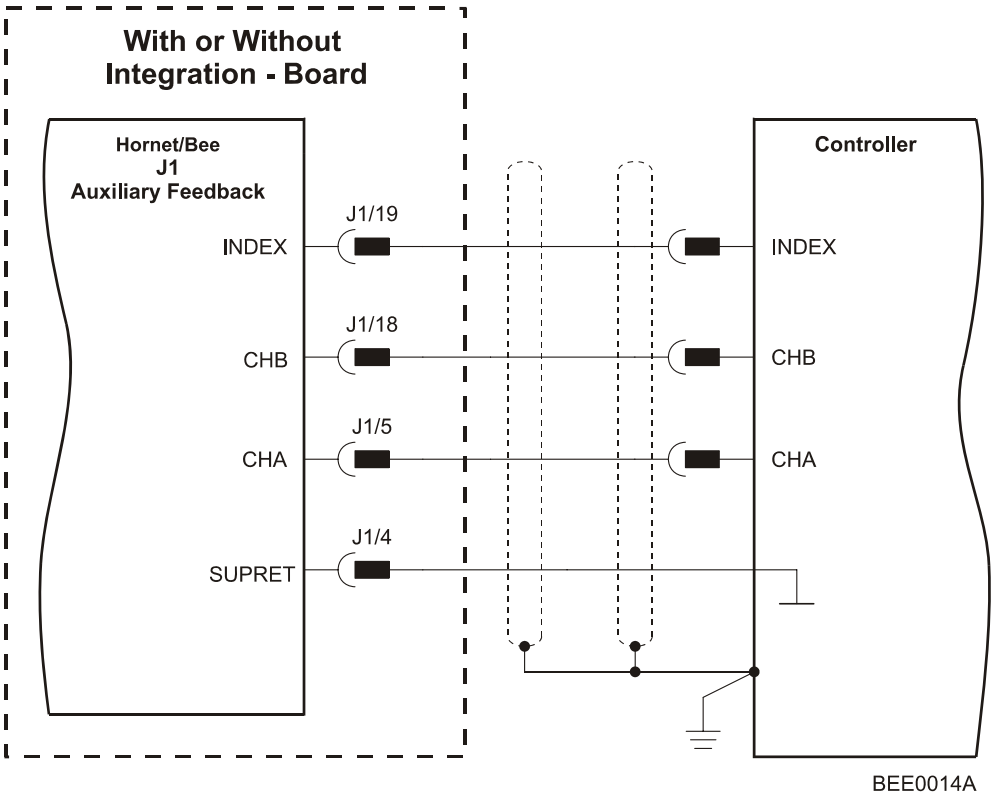


Figure 3-15: Emulated Encoder Direct Output – Acceptable Connection Diagram

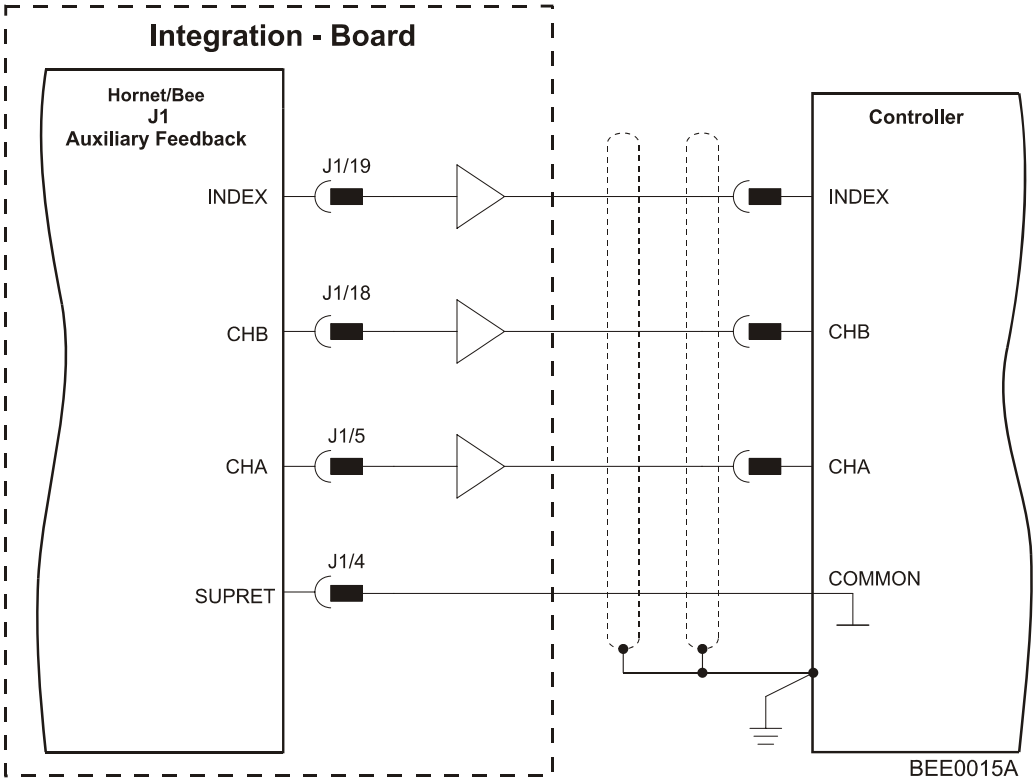


Figure 3-16: Emulated Encoder Buffered Output – Recommended Connection Diagram

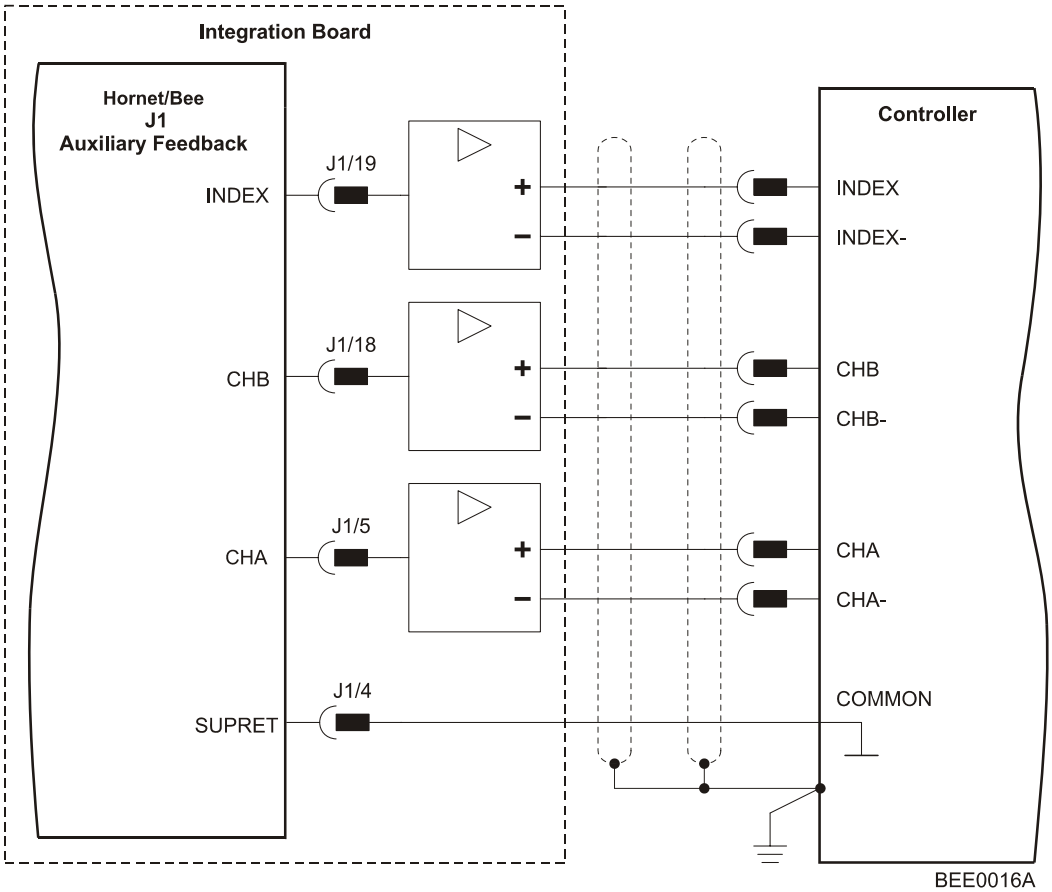


Figure 3-17: Emulated Encoder Differential Output – Highly Recommended Connection Diagram

3.10.3 Auxiliary Feedback: Single-Ended Encoder Input Option (YA[4]=2)

Pin	Signal	Function
J1/4	SUPRET	Supply return
J1/19	INDEX	Auxiliary index input
J1/18	CHB	Auxiliary channel B input
J1/5	CHA	Auxiliary channel A input

Note: The Hornet and Bee's Auxiliary Feedback is single-ended. When mounted on an integration board, circuitry can be added to make it differential.

Pin Position

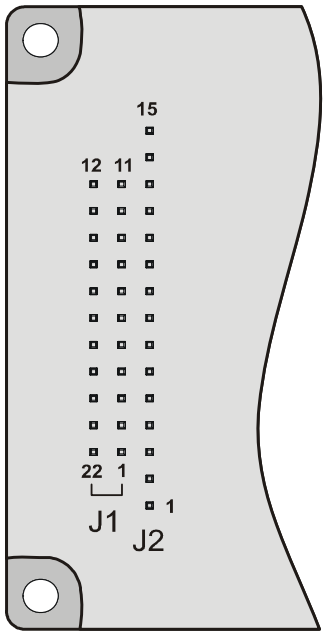


Table 3-5: Single-Ended Auxiliary Encoder Pin Assignment

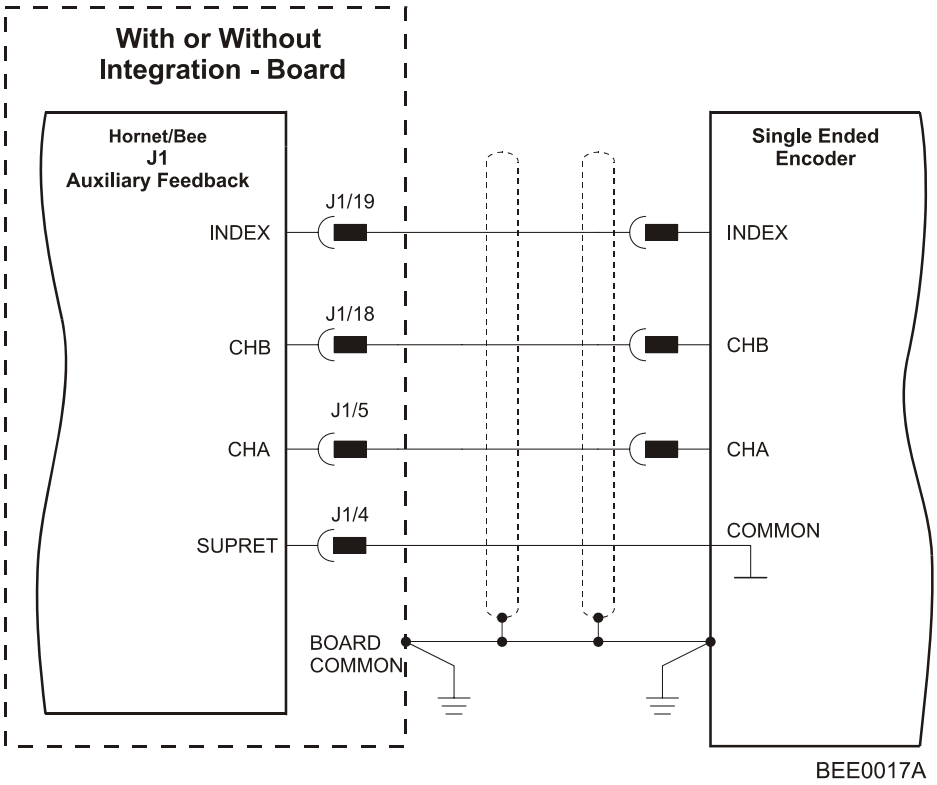


Figure 3-18: Single-ended Auxiliary Encoder Input - Acceptable Connection Diagram

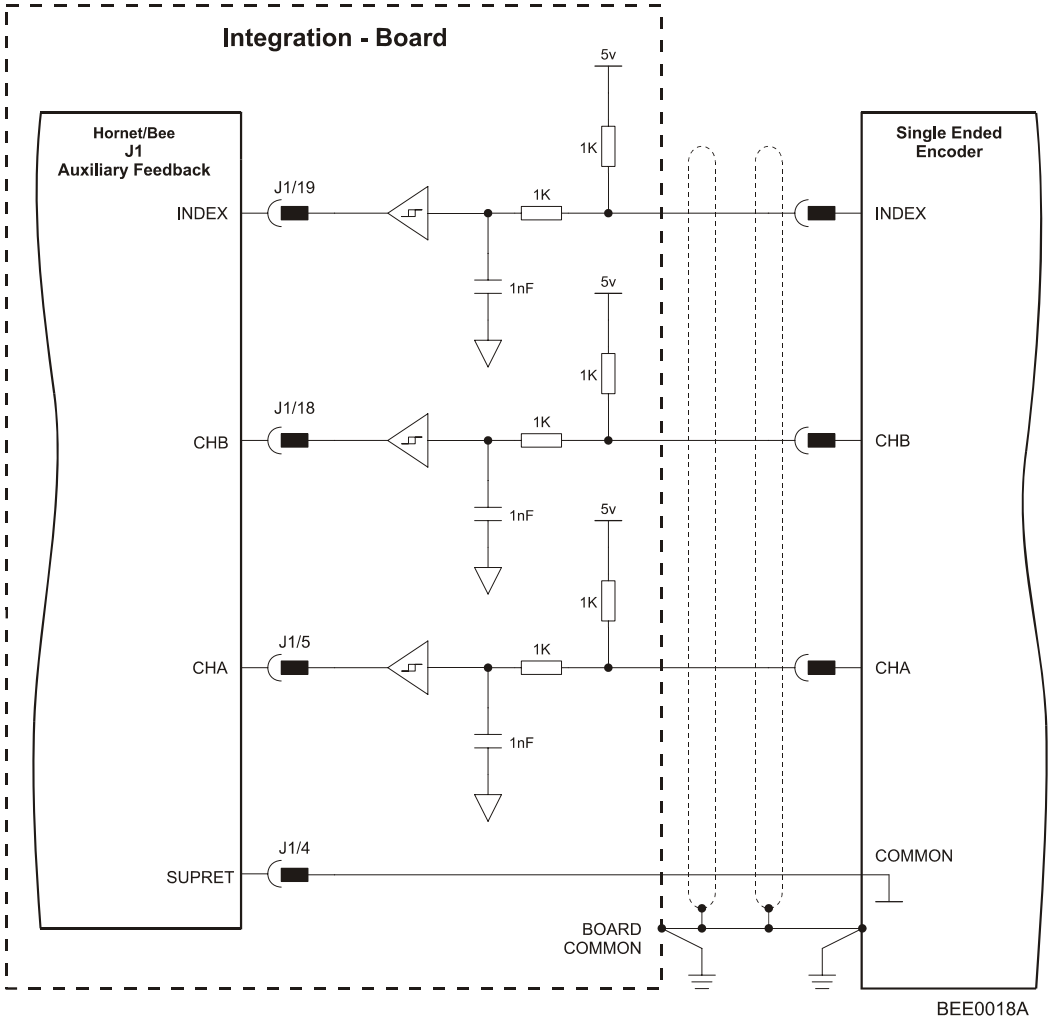


Figure 3-19: Single-ended Auxiliary Encoder Input - Recommended Connection Diagram

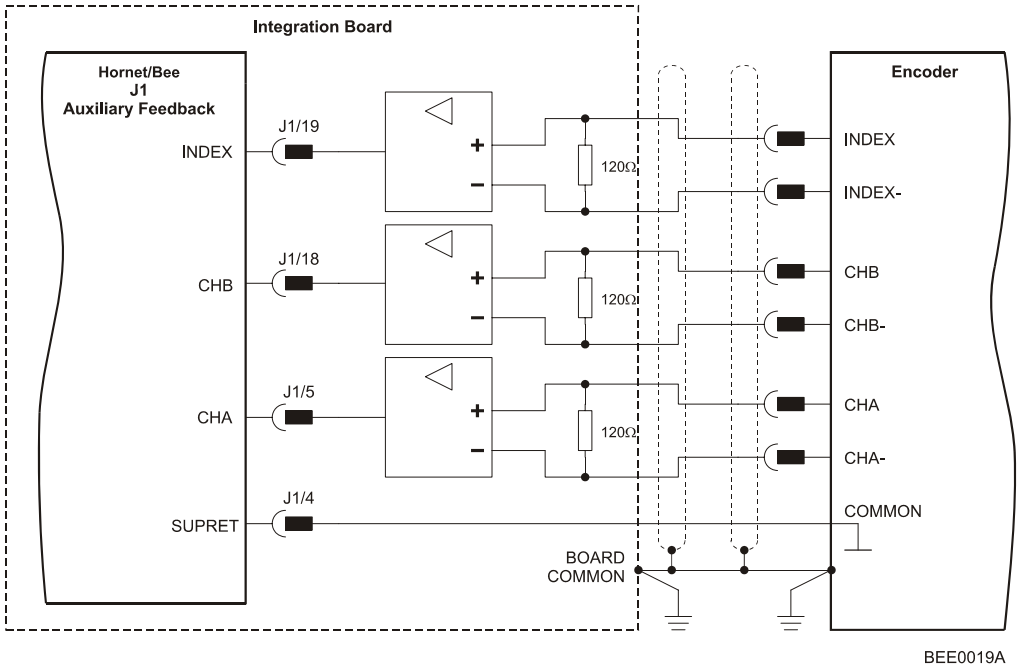
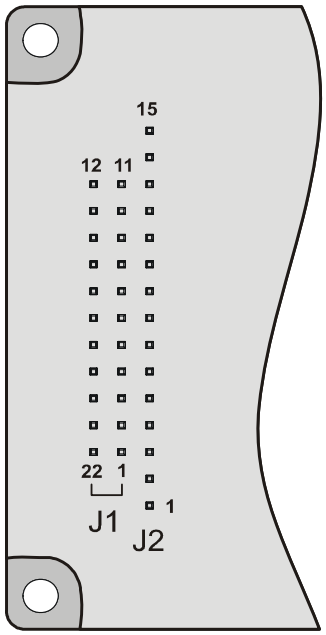


Figure 3-20: Differential Auxiliary Encoder Input – Highly Recommended Connection Diagram

3.10.4 Auxiliary Feedback: Pulse-and-Direction Input Option (YA[4]=0)

Pin	Signal	Function	Pin Position
J1/4	SUPRET	Supply return	
J1/18	DIR/CHB	Direction input (push/pull 5 V or open collector)	
J1/5	PULS/CHA	Pulse input (push/pull 5 V or open collector)	

Note: The Hornet and Bee's Auxiliary Feedback is single-ended. When mounted on an integration board, circuitry can be added to make it differential.

Table 3-6: Pulse-and-Direction Pin Assignments

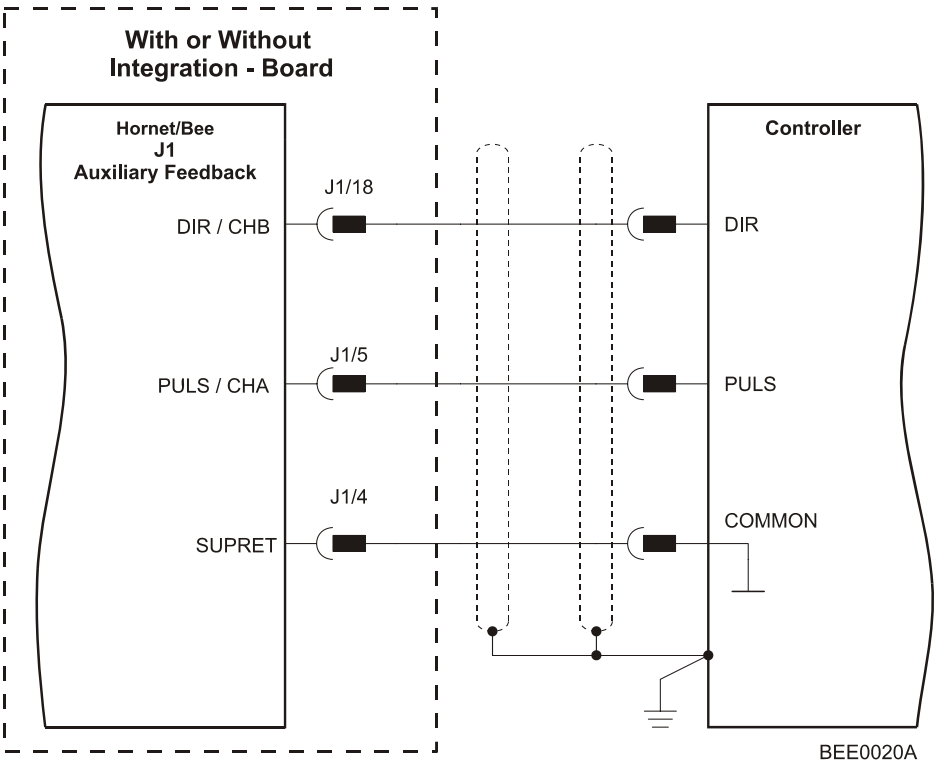


Figure 3-21: Pulse-and-Direction Auxiliary Encoder Input – Direct Connection Diagram

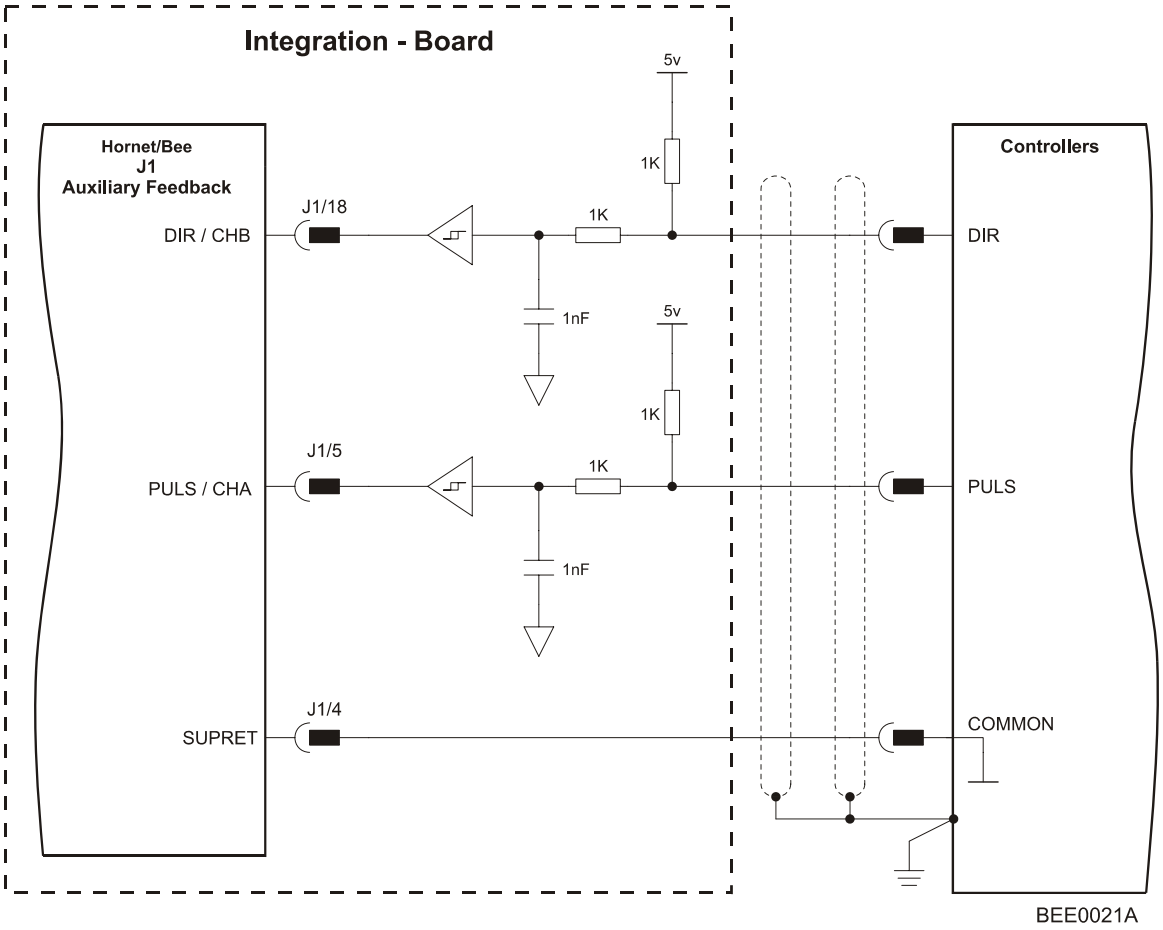


Figure 3-22: Pulse-and-Direction Auxiliary Encoder Input – Buffered Connection Diagram

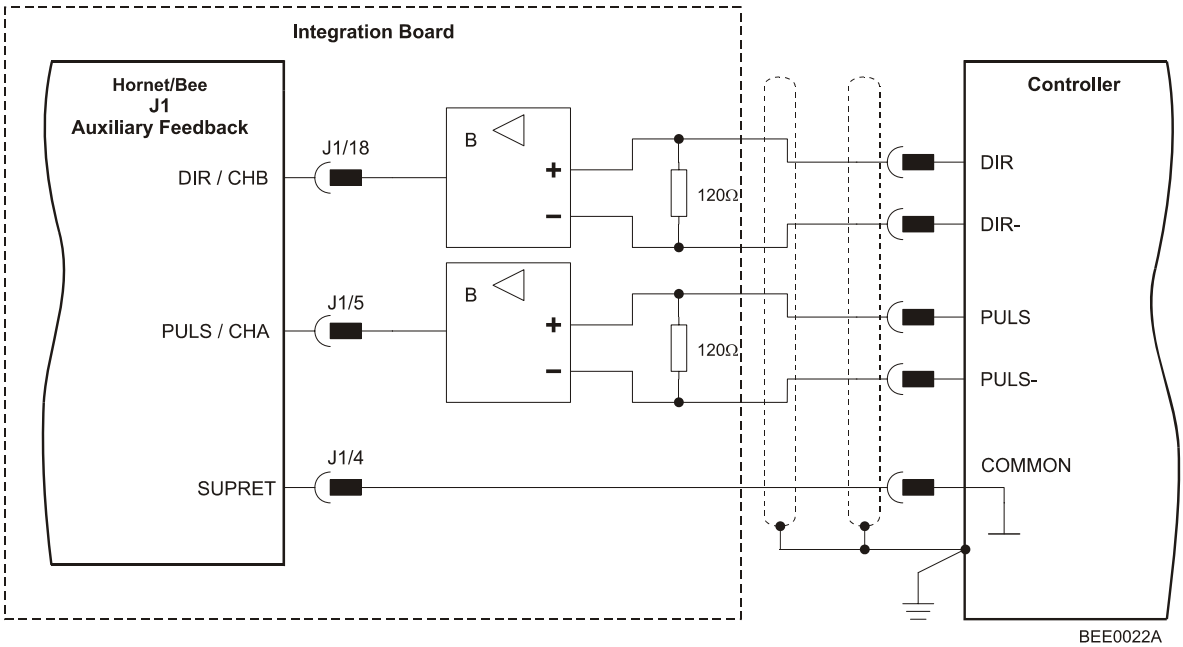


Figure 3-23: Pulse-and-Direction Auxiliary Encoder Input – Differential Connection Diagram

3.11 I/Os

The Hornet and Bee have 6 Digital Inputs, 2 Digital Outputs and 1 Analog Input.

I/O	J1	J2	Total
Digital Input	6	-	6
Digital Output	2	-	2
Analog Input	-	1	1

3.11.1 Digital Input

Each of the pins below can function as an independent input.

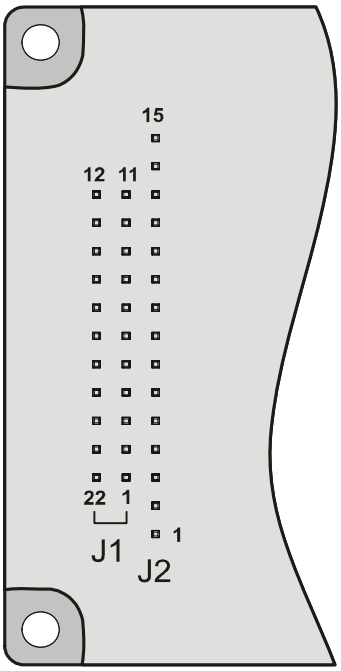
Pin	Signal	Function	Pin Position
J1/9	IN1	Programmable input 1 (general purpose, RLS, FLS, INH)	
J1/10	IN2	Programmable input 2 (general purpose, RLS, FLS, INH)	
J1/11	IN3	Programmable input 3 (general purpose, RLS, FLS, INH)	
J1/12	IN4	Programmable input 4 (general purpose, RLS, FLS, INH)	
J1/13	IN5	Hi-Speed Programmable input 5 (event capture, Main Home, general purpose, RLS, FLS, INH)	
J1/14	IN6	Hi-Speed Programmable input 6 (event capture, Auxiliary Home, general purpose, RLS, FLS, INH)	
J1/15	INRET	Programmable input return	

Table 3-7: ***Digital Input Pin Assignments***

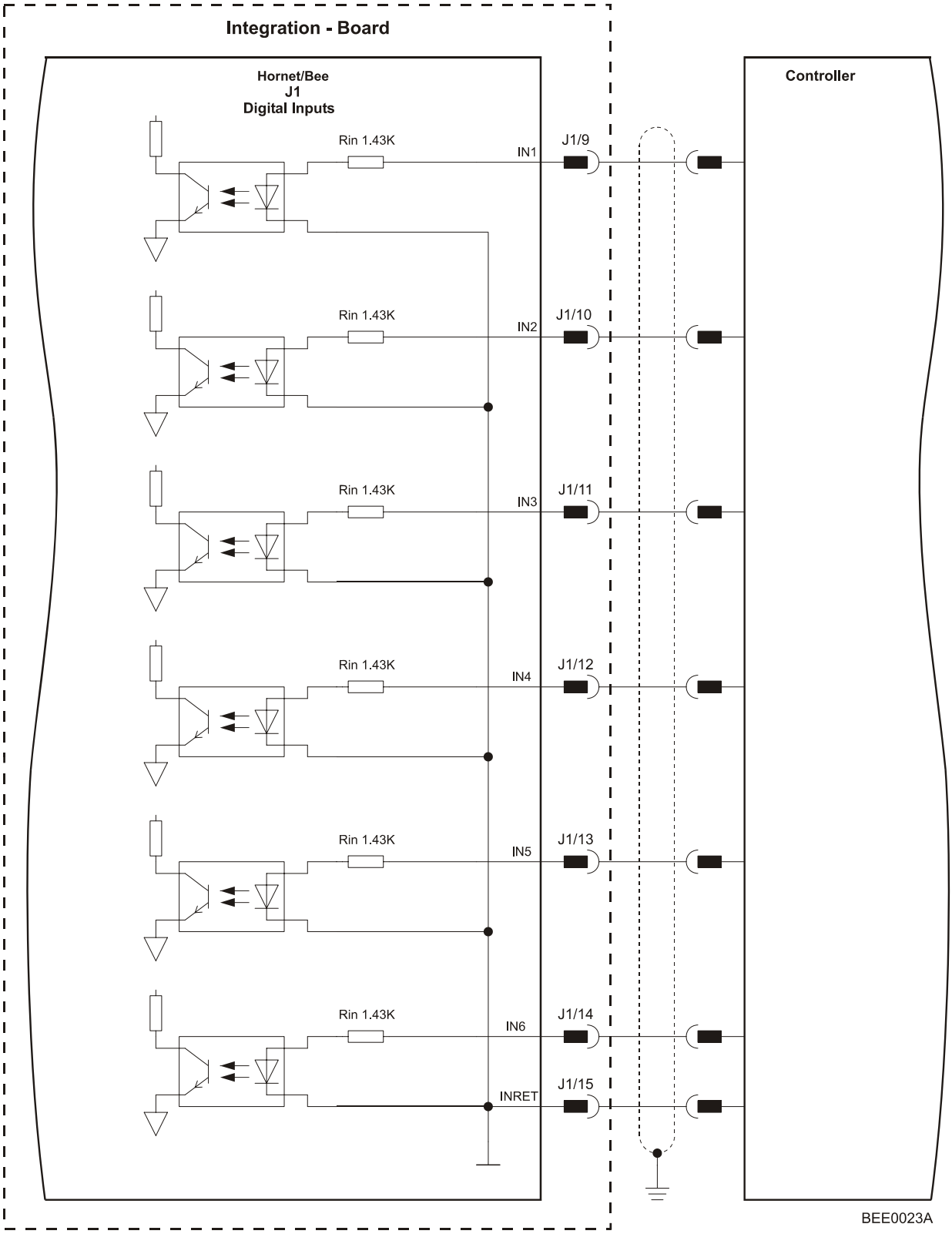


Figure 3-24: ***Digital Input Connection Diagram***

3.11.2 Digital Output

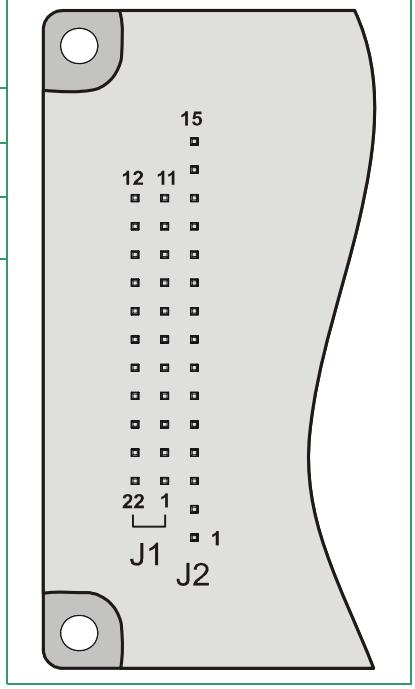
Pin	Signal	Function	Pin Position
J1/7	OUT1	High-Speed Programmable digital output 1	
J1/17	OUTRET1	Programmable digital output return 1	
J1/8	OUT2	Programmable digital output 2	
J1/16	OUTRET2	Programmable digital output return 2	

Table 3-8: ***Digital Output Pin Assignment***

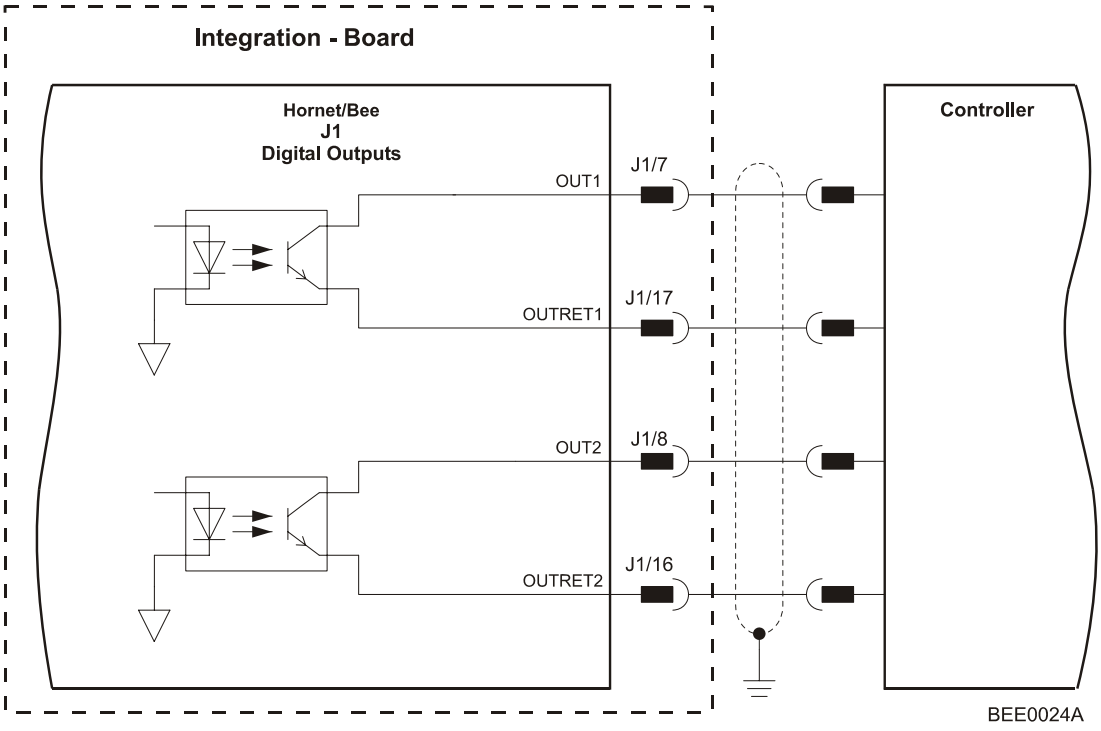


Figure 3-25: ***Digital Output Connection Diagram***

3.11.3 Analog Input

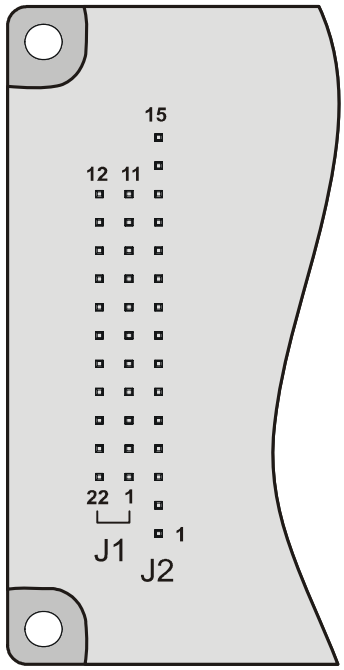
Pin	Signal	Function	Pin Position
J2/3	ANLIN1+	Analog input 1+	
J2/4	ANLIN1-	Analog input 1-	
J2/2	ANLRET	Analog ground	

Table 3-9: ***Analog Input Pin Assignments***

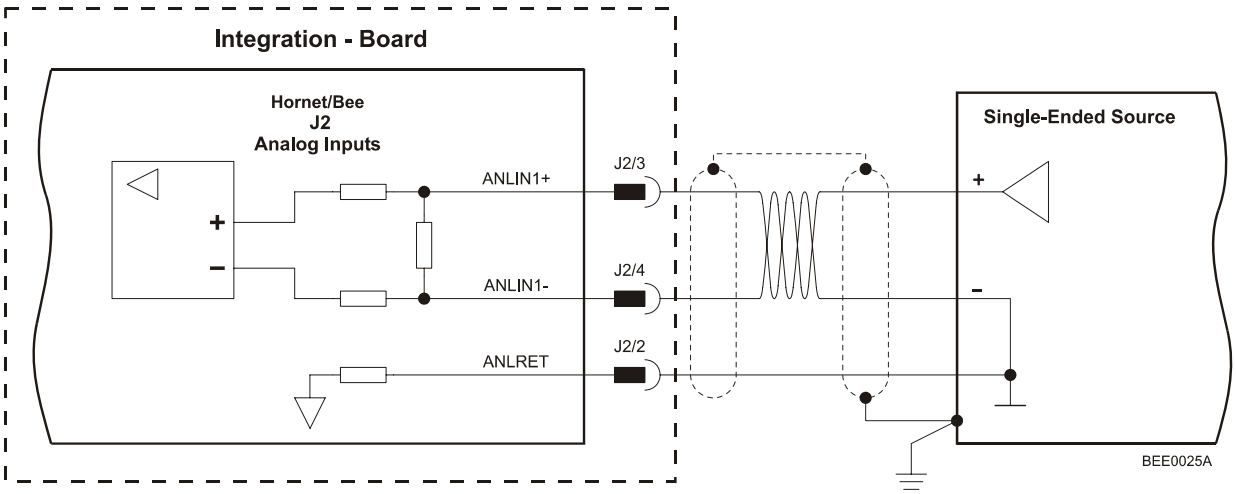


Figure 3-26: ***Analog Input with Single-ended Source***

3.12 Communications

The communication interface may differ according to the user's hardware. The Hornet and Bee can communicate using the following options:

a. RS-232, full duplex
b. CANopen

RS-232 communication requires a standard, commercial 3-core null-modem cable connected from the Hornet or Bee to a serial interface on the PC. The interface is selected and set up in the Composer software.

In order to benefit from **CANopen** communication, the user must have an understanding of the basic programming and timing issues of a CANopen network.

For ease of setup and diagnostics of CAN communication, RS-232 and CANopen can be used simultaneously.

3.12.1 RS-232 Communication

Notes for connecting the RS-232 communication cable:

- Connect the shield to the ground of the host (PC). Usually, this connection is soldered internally inside the connector at the PC end. You can use the drain wire to facilitate connection.
- The RS-232 communication port is **non-isolated**.
- Ensure that the shield of the cable is connected to the shield of the connector used for RS-232 communications. The drain wire can be used to facilitate the connection.

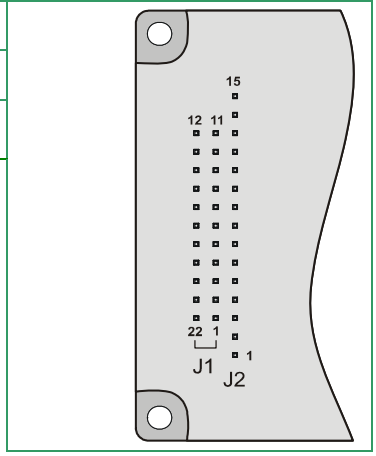
Pin	Signal	Function	Pin Location
J1/1	RS232_Rx	RS-232 receive	
J1/2	RS232_Tx	RS-232 transmit	
J1/3	RS232_COMRET	Communication return	

Table 3-10: ***RS-232 Pin Assignments***

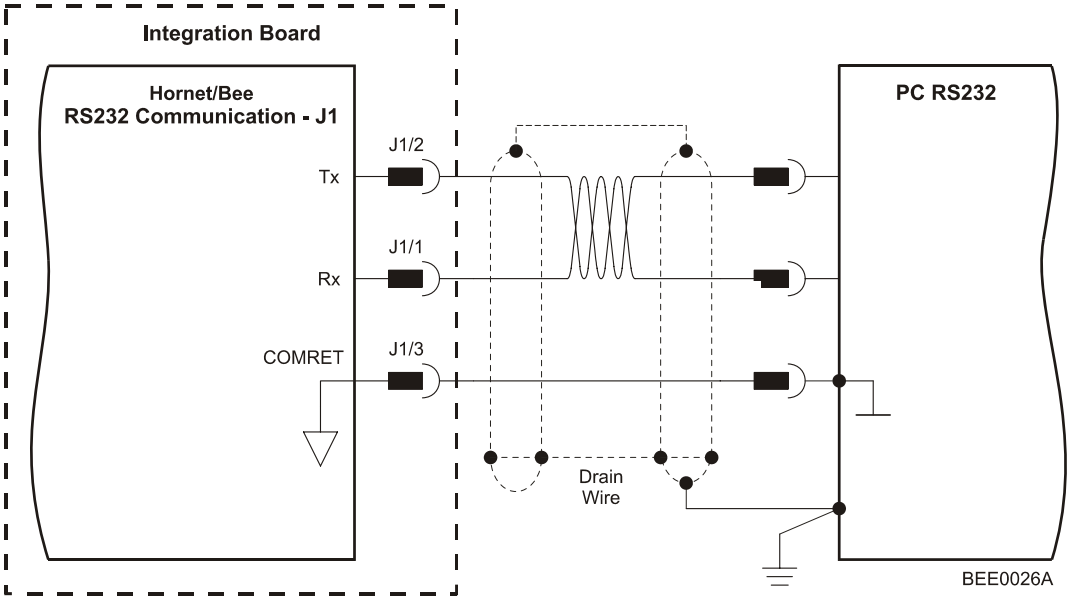


Figure 3-27: ***RS-232 Connection Diagram***

3.12.2 CANopen Communication

Notes for connecting the CANopen communication cable:

- Connect the shield to the ground of the host (PC). Usually, this connection is soldered internally inside the connector at the PC end. You can use the drain wire to facilitate connection.
- Ensure that the shield of the cable is connected to the shield of the connector used for communications. The drain wire can be used to facilitate the connection.
- Make sure to have a 120-ohm resistor termination at each of the two ends of the network cable.
- The Hornetand Bee's CAN ports are **non-isolated**.

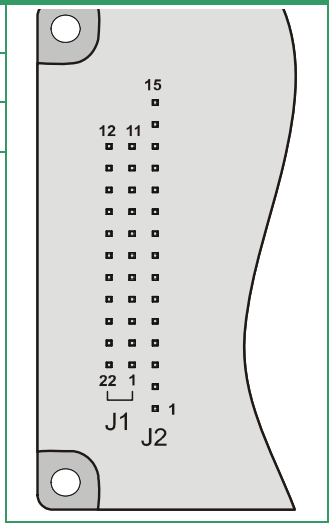
Pin	Signal	Function	Pin Position
J1/20	CAN_GND	CAN ground	
J1/21	CAN_L	CAN_L busline (dominant low)	
J1/22	CAN_H	CAN_H busline (dominant high)	

Table 3-11: ***CANopen - Pin Assignments***

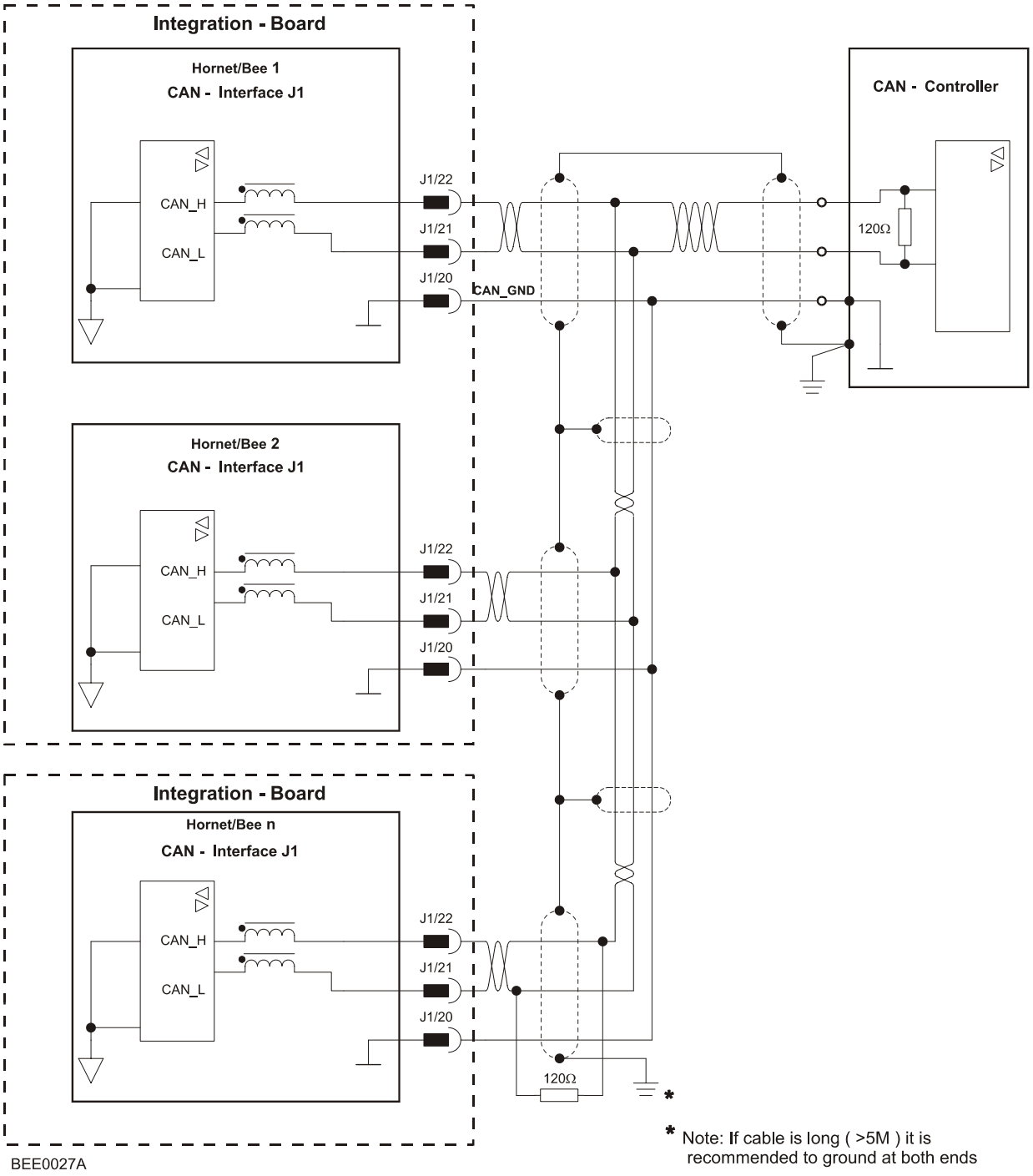


Figure 3-28: ***CANopen Network Diagram***

Caution:

When installing CANopen communication, ensure that each servo drive is allocated a unique ID. Otherwise, the CANopen network may hang.

3.13 Powering Up

After the Hornet or Bee is connected to its device, it is ready to be powered up.

Caution:
Before applying power, ensure that the DC supply is within the specified range and that the proper plus-minus connections are in order.

3.14 Initializing the System

After the Hornet/Bee have been connected and mounted, the system must be set up and initialized. This is accomplished using the *Composer*, Elmo's Windows-based software application. Install the application and then perform setup and initialization according to the directions in the *Composer Software Manual*.

3.15 Heat Dissipation

3.15.1 Hornet Thermal Data

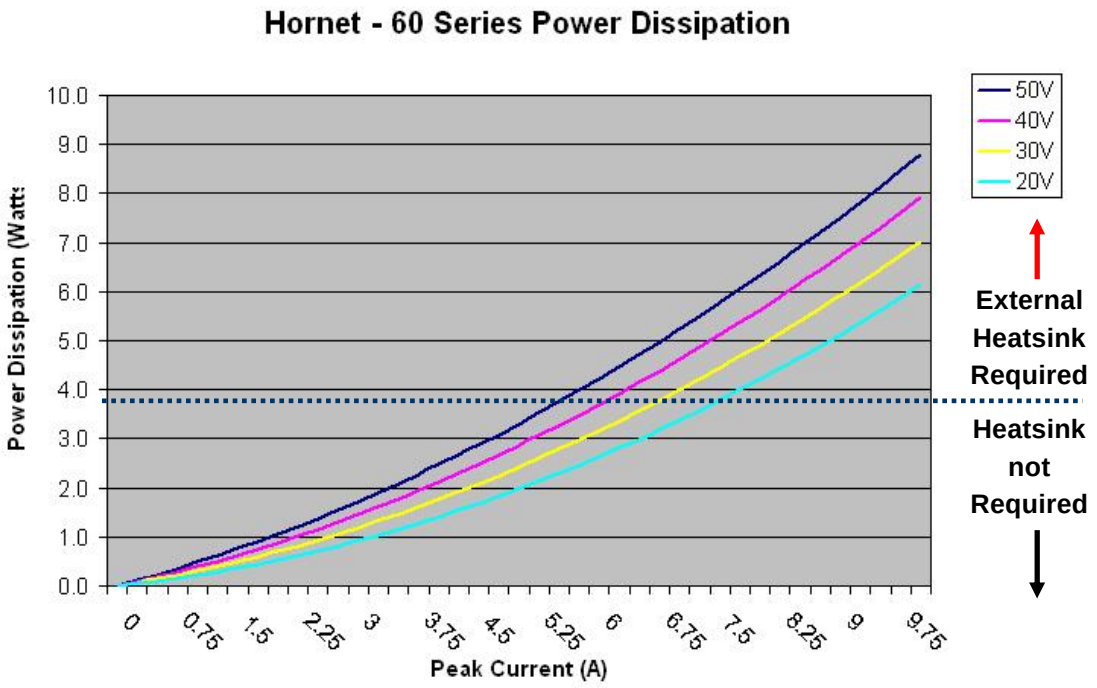
The best way to dissipate heat from the Hornet is to mount it so that its heatsink faces up. For best results leave approximately 10 mm of space between the Hornet's heatsink and any other assembly.

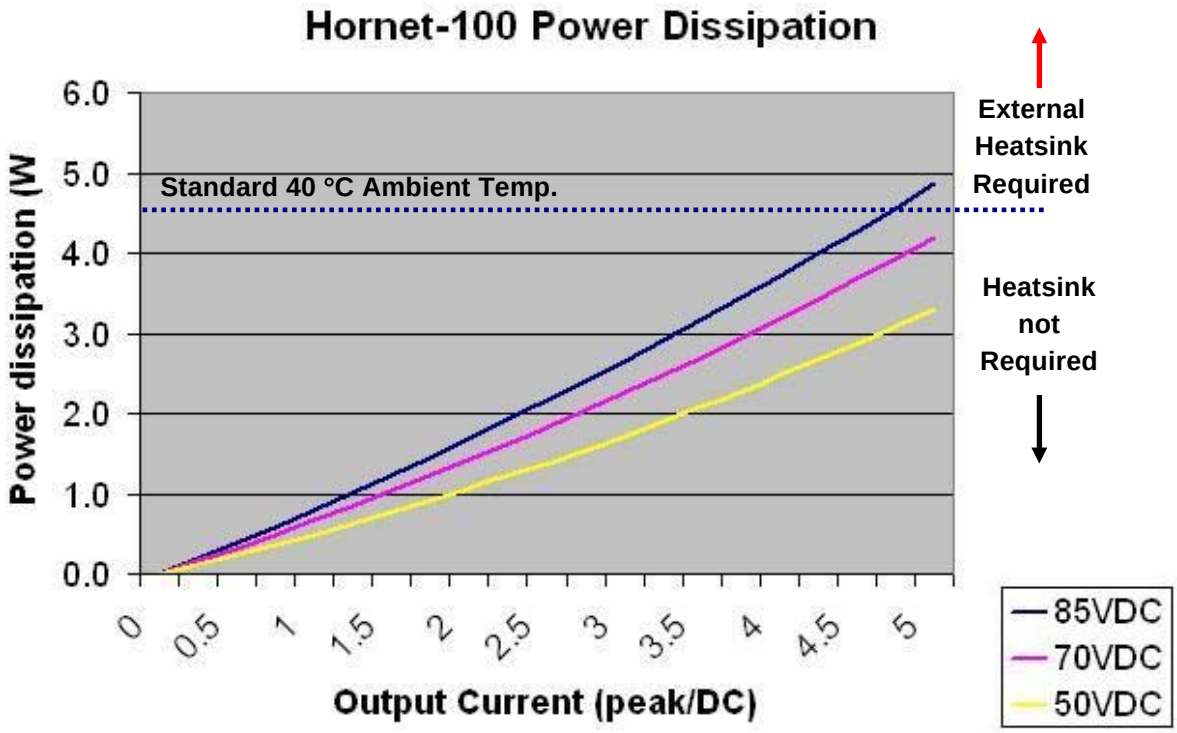
3.15.1.1 Hornet Thermal Data

- Heat dissipation capability (θ): Approximately 10°C/W.
- Thermal time constant: Approximately 240 seconds (thermal time constant means that the Hornet will reach 2/3 of its final temperature after 4 minutes).
- Shut-off temperature: 86°C – 88°C (measured on the heatsink)

3.15.1.2 Heat Dissipation Data

Heat Dissipation is shown in graphically below:





3.15.1.3 How to Use the Charts

The charts above are based upon theoretical worst-case conditions. Actual test results show 30% - 50% better power dissipation.

To determine if your application needs a heatsink:

1. Allow maximum heatsink temperature to be 80°C or less.

2. Determine the ambient operating temperature of the Hornet.
3. Calculate the allowable temperature increase as follows:
   - for an ambient temperature of 40°C , ΔT= 80°C - 40°C = 40 °C
4. Use the chart to find the actual dissipation power of the drive. Follow the voltage curve to the desired output current and then find the dissipated power.
5. If the dissipated power is below 4W the Hornet will need no additional cooling.

Note: The chart above shows that no heatsink is needed when the heatsink temperature is 80°C, ambient temperature is 40°C and heat dissipated is 4 Watts:

3.15.2 Bee Thermal Data

The best way to dissipate heat from the Bee is to mount it so that its lower board faces upward. For best results leave approximately 10 mm of space between the Bee's lower board and any other assembly.

3.16 Evaluation Board and Cable Kit

The same circuit board used for the Whistle and Tweeter is also available for evaluating the Hornet and Bee. It comes with standards terminal blocks for power connections and D-sub plugs/sockets for signals connections. The Evaluation Board is provided with a cable kit.

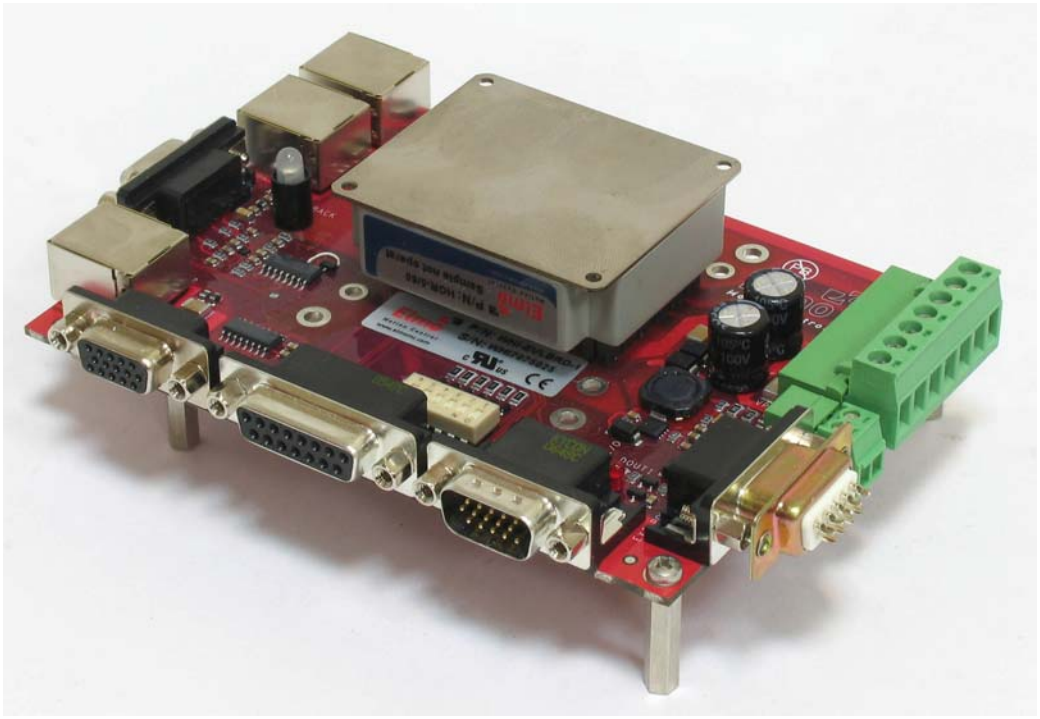


Figure 3-29: **The Hornet Mounted on an Evaluation Board (available upon request)**

Evaluation Board Catalog Number	WHI-EVLBRD-1
Evaluation Board User Manual	MAN-EVLBRD-WHI (available on our web site)

Appendix: Hornet and Bee Technical Specifications

A.1 Features

A.1.1 Motion Control Modes

- Current/Torque - up to 14 KHz sampling rate
- Velocity - up to 7 KHz sampling rate
- Position - up to 3.5 KHz sampling rate

A.1.2 Advanced Positioning Control Modes

- PTP, PT, PVT, ECAM, Follower, Dual Loop, Current Follower
- Fast event capturing inputs
- Fast output compare (OC)
- Motion Commands: Analog current and velocity, PWM current and velocity, digital (SW) and Pulse and Direction

A.1.3 Advanced Filters and Gain Scheduling

- "On-the-Fly" gain scheduling of current and velocity
- Velocity and position with "1-2-4" PIP controllers
- Automatic commutation alignment
- Automatic motor phase sequencing

A.1.4 Fully Programmable

- Third generation programming structure with motion commands - "Metronome"
- Event capturing interrupts
- Event triggered programming

A.1.5 Feedback Options

- Incremental Encoder – up to 20 Mega-Counts (5 Mega-Pulse) per second
- Digital Halls – up to 2 KHz
- Incremental Encoder with Digital Halls for commutation – up to 20 Mega-Counts per second for encoder
- Interpolated Analog Sine/Cosine Encoder – up to 250 KHz (analog signal)
  - Internal Interpolation - up to x4096
  - Automatic Correction of amplitude mismatch, phase mismatch, signal offset
  - Emulated encoder outputs, single-ended, unbuffered of the Analog encoder
- Analog Hall Sensor
- Resolver
  - Programmable 10~15 bit resolution
  - Up to 512 Revolution Per Second (RPS)
  - Emulated encoder outputs, single-ended, unbuffered of the Resolver.
- Auxiliary Encoder inputs (ECAM, follower, etc.) single-ended, unbuffered.
- Tachometer & Potentiometer

- Provide power (5V, 200mA max) for one Encoder, Resolver or Hall.

A.1.6 Input/Output

- One **Analog Input** – up to 14-bit resolution
- Six programmable **Digital Inputs**, optically isolated (two of which are fast event capture inputs).
    - Inhibit \ Enable motion
    - Software and analog reference stop
    - Motion limit switches
    - Begin on input
    - Abort motion
    - Homing
    - General-purpose
- Two programmable **Digital Outputs**, optically isolated (open collector) one with fast output compare (OC)
    - Brake Control
    - Amplifier fault indication
    - General-purpose
    - Servo enable indication
- Pulse and Direction inputs (single-ended)
- PWM current command output for torque and velocity

A.1.7 Built-In Protection

- Software error handling
- Abort (hard stops and soft stops)
- Status reporting
- Protection against:
    - Shorts between motor power outputs
    - Shorts between motor power output and power input
    - Failure of internal power supplies
    - Over temperature
        - Cont. temperature measurement. Temp can be read on the fly, Warning can be initiated X degrees before temp disable is activated.
    - Over/Under voltage
    - Loss of feedback
    - Following error
    - Current limits

A.1.8 Accessories

- Heat sinks (TBD)
- Evaluation Board/Cable Kit

A.1.9 Status Indication

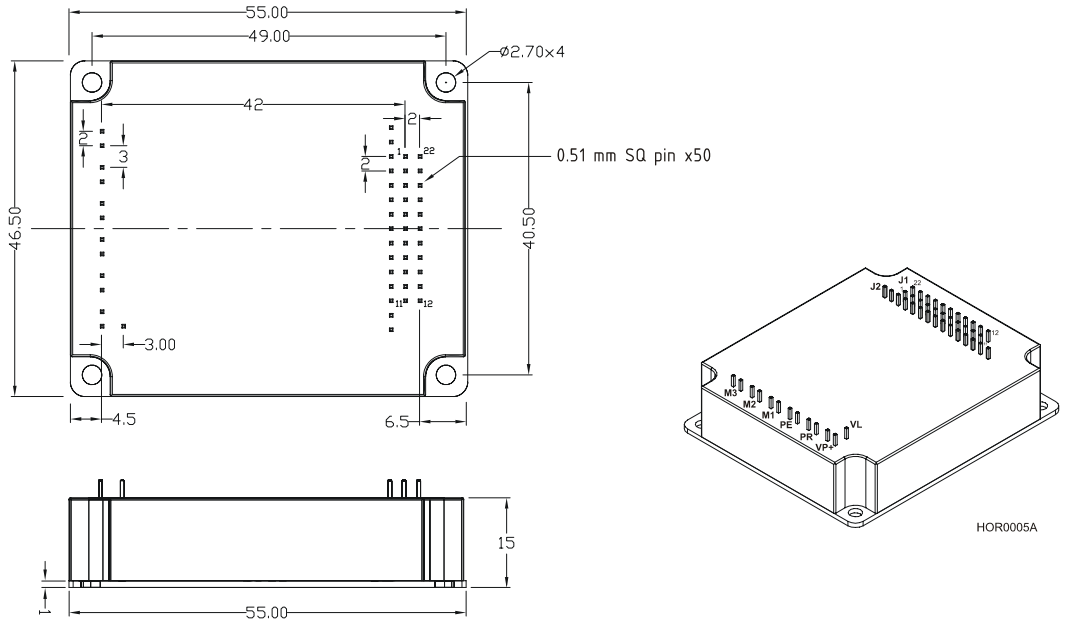
- Output for a bi-color LED

A.1.10 Automatic Procedures

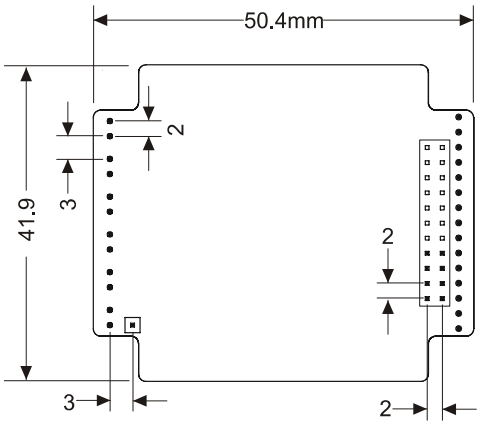
- Commutation alignment
- Phase sequencing
- Current loop offset adjustment
- Current loop gain tuning
- Current gain scheduling
- Velocity loop offset adjustment
- Velocity gain tuning
- Velocity gain scheduling
- Position gain tuning

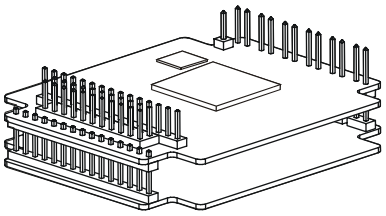
A.2 Dimensions

A.2.1 Hornet

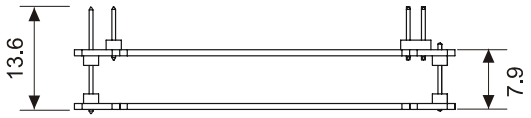


A.2.2 Bee





BEE0028A



A.3 Power Ratings

A.3.1 Hornet

Feature	Unit	15/48	5/60	10/60	15/60	2.5/100	5/100	15/100
Minimum supply voltage	VDC	6	7.5			12		
Nominal supply voltage	VDC	42	50			85		
Maximum supply voltage	VDC	48	59			95		
Max. output power from the drive without heatsink	W	580	240	480	720	200	400	1200
Efficiency at rate power	%	> 99						
Output Voltage	%	> 95% of supply VDC at f=22 KHz						
DC and Trapezoidal Commutation Continuous Current Limit (Ic)	A	15	5	10	15	2.5	5	15
Sinusoidal Commutation Continuous RMS Current Limit (Ic)	A	10.6	3.5	7	10.6	1.8	3.5	10.6
Peak current limit (RMS)	A	2 x Ic						
PWM Switching Frequency	KHz	22 +/-5% default on the motor						
Switching Method		Advanced Unipolar PWM						
Weight		~ 50 grams (1.8 ounces)						

Dimensions	55 x 15 x 46.5 mm (2.2" x 0.6″ x 1.8″)
Digital In / Digital Out / Analog In	6 / 2 / 1
Mounting Method	PCB Mount or soldered pins and 4 screws

A.3.2 Bee

Feature	**Unit**	**3/60**	**2.5/100**
Minimum supply voltage	VDC	7.5	12
Nominal supply voltage	VDC	50	85
Maximum supply voltage	VDC	59	95
Max. output power from the drive without heatsink	W	160	200
Efficiency at rate power	%	> 99	
Output Voltage	%	> 95% of supply VDC at f=22 KHz	
DC and Trapezoidal Commutation Continuous Current Limit (Ic)	A	3.3	2.5
Sinusoidal Commutation Continuous RMS Current Limit (Ic)	A	2.4	1.8
Peak current limit (RMS)	A	2 x Ic	
PWM Switching Frequency	KHz	22 +/-5% default on the motor	
Switching Method		Advanced Unipolar PWM	
Weight		~27 grams (.95 oz)	
Dimensions		51 x 12.5 x 42 mm (2 x 0.49″ x 1.65″)	
Digital In / Digital Out / Analog In		6 / 2 / 1	
Mounting Method		PCB Mount or soldered pins	

A.4 Environmental Conditions

Ambient Temperature Range	Non-Operating Condition	-50°C to +100°C (-58°F to 212°F)
	Operating Condition	-40°C to +71°C (-40°F to 160°F)
Temperature Shock	Non-Operating Condition	-40°C to +71°C (-40°F to 160°F) within 3 min.
Altitude	Non-Operating	Unlimited

	Condition		
	Operating Condition	-400 to 150,000m (-1,000 to 510,000 ft)	
Relative Humidity	Non-Operating Condition	up to 95% relative humidity non-condensing at 35°C (95°F)	
	Operating Condition	up to 95% relative humidity non-condensing at 25°C (77°F), up to 90% relative humidity non-condensing at 42°C (108°F)	
Vibration	Operating Condition	20 Hz -2000 Hz, 14.6 g	
Mechanical Shock	Non-Operating Condition	±40 g	Half sine, 11 msec.
	Operating Condition	±20 g	Half sine, 11 msec.

A.4.1 Auxiliary Supply

Feature	Details
Auxiliary power supply	*Isolated DC source only*
Auxiliary supply input voltage	12 VDC ~ 95 VDC
Auxiliary supply input power	< 2.5 VA (this includes the 5V/200mA load for the main encoder only)

A.5 Control Specifications

A.5.1 Current Loop

Feature	Details
Controller type	Vector, digital
Compensation for bus voltage variations	"On-the-fly" automatic gain scheduling
Motor types	▪ AC brushless (sinusoidal) ▪ DC brushless (trapezoidal) ▪ DC brush ▪ Linear motors ▪ "Voice" coils
Current control	▪ Fully digital ▪ Sinusoidal with vector control ▪ Programmable PI control filter based on a pair of PI controls of AC current signals and constant power at high speed

Feature	Details
Current loop bandwidth	> 2.5 KHz
Current sampling time	Programmable 70 - 100 µsec
Current sampling rate	up to 16 KHz

A.5.2 Velocity Loop

Feature	Details
Controller type	PI
Velocity control	▪ Fully digital ▪ Programmable PI and FFW control filters ▪ "On-the-fly" gain scheduling ▪ Automatic, manual and advanced manual tuning
Velocity and position feedback options	▪ Incremental Encoder ▪ Digital Halls ▪ Interpolated Analog (sin/cos) Encoder (optional) ▪ Resolver (optional) ▪ Tachometer and Potentiometer (optional) **Note:** With all feedback options, 1/T with automatic mode switching is activated (gap, frequency and derivative).
Velocity loop bandwidth	> 350 Hz
Velocity sampling time	140 - 200 µsec (x2 current loop sample time)
Velocity sampling Rate	up to 8 KHz
Velocity command options	▪ Analog ▪ Internally calculated by either jogging or step **Note:** All software-calculated profiles support on-the-fly changes.

A.5.3 Position Loop

Feature	Details
Controller type	"1-2-4" PIP
Position command options	▪ Software ▪ Pulse and Direction ▪ Analog Potentiometer

Feature	Details
Position loop bandwidth	> 80 Hz
Position sampling time	280 - 400 μsec (x 4 current loop sample time)
Position sampling rate	up to 4 KHz

A.6 Feedbacks

A.6.1 Feedback Supply Voltage

The Hornet and Bee have two feedback ports (Main and Auxiliary). The drives supply voltage only to the main feedback device. The user must provide a separate power supply for auxiliary feedback devices if needed.

Feature	Details
Main encoder supply voltage	5 V ±5% @ 200 mA maximum

A.6.2 Main Feedback Options

A.6.2.1 Incremental Encoder Input

Feature	Details
Encoder format	▪ A, B and Index ▪ Differential ▪ Quadrature
Interface	RS-422
Input resistance	Differential: 120 Ω (TBD)
Maximum incremental encoder frequency	Maximum absolute: 5 MHz pulses
Minimum quadrature input period (P_{IN})	112 nsec
Minimum quadrature input high/low period (P_{HL})	56 nsec
Minimum quadrature phase period (P_{PH})	28 ns
Maximum encoder input voltage range	Common mode: ±7V Differential mode: ±7V

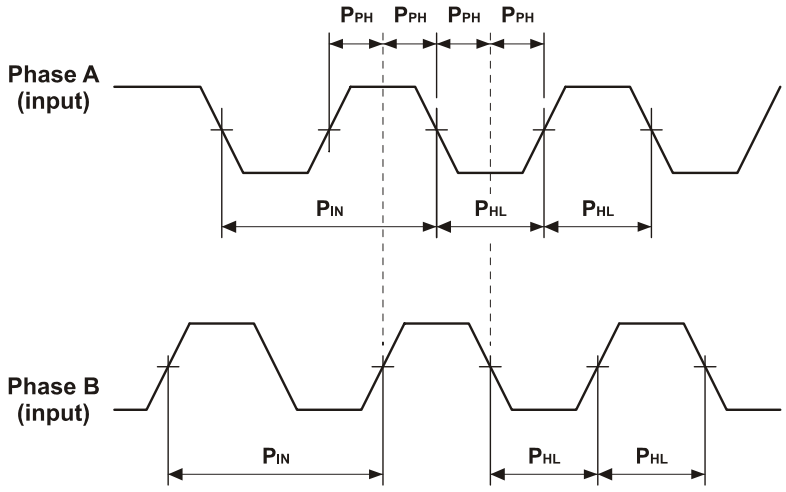


Figure A-1: Main Feedback - Encoder Phase Diagram

A.6.2.2 Digital Halls

Feature	Details
Halls inputs	▪ H_A, H_B, H_C. ▪ Single ended inputs ▪ Built in hysteresis of 1V for noise immunity
Input voltage	Nominal operating range: $0V < V_{In_Hall} < 5V$ Maximum absolute: $-1V < V_{In_Hall} < 15V$ High level input voltage: $V_{InHigh} > 2.5V$ Low level input voltage: $V_{InLow} < 1V$
Input current	Sink current (when input pulled to the common): 3ma Source current: 1.5 ma (designed to also support open collector Halls)
Maximum frequency	f_{MAX} : 2 KHz

A.6.2.3 Interpolated Analog Encoder (Sine/Cosine)

Feature	Details
Analog encoder format	Sine and Cosine signals
Analog input signal level	▪ Offset voltage: 2.2 V – 2.8 V ▪ Differential, 1 V peak to peak
Input resistance	Differential 120 Ω
Maximum analog signal frequency	f_{MAX} : 250 kHz
Interpolation multipliers	Programmable: x4 to x4096
Maximum "counts" frequency	80 mega-counts/sec "internally"

Feature	Details
Automatic errors correction	Signal amplitudes mismatch Signal phase shift Signal offsets
Encoder outputs	See Auxiliary Encoder Outputs specifications (A.6.3)

A.6.2.4 Resolver

Feature	Details
Resolver format	▪ Sine/Cosine ▪ Differential
Input resistance	Differential 2.49 KΩ
Resolution	Programmable: 10 ~ 15 bits
Maximum electrical frequency (RPS)	512 revolutions/sec
Resolver transfer ratio	0.5
Reference frequency	1/Ts (Ts = sample time in seconds)
Reference voltage	Supplied by the Hornet and Bee
Reference current	up to ±50 mA
Encoder outputs	See Auxiliary Encoder Output specifications (A.6.3)

A.6.2.5 Tachometer*

Feature	Details
Tachometer format	Differential
Maximum operating differential voltage for TAC1+, TAC1-	+/- 20V
Maximum absolute differential input voltage for TAC1+, TAC1-	+/-25V
Maximum operating differential voltage for TAC2+, TAC2-	+/- 50V
Maximum absolute differential input voltage for TAC2+, TAC2-	+/- 60V
Input resistance for TAC1+, TAC1-	46 KΩ
Input resistance for TAC2+, TAC2-	100 KΩ
Resolution	14 bit

* Only one Tachometer port can be used at a time (either TAC1+/TAC1- or TAC2+/TAC2-).
TAC1+/TAC1- is used in applications with having a Tachometer of less than 20V.
TAC2+/TAC2- is used in applications with having a Tachometer of between 20V and 50V.

A.6.2.6 Potentiometer

Feature	Details
Potentiometer Format	Single-ended
Operating Voltage Range	0 ~ 5V supplied by the Hornet and Bee
Potentiometer Resistance	100Ω ~ 1 KΩ … above this range, linearity is affected detrimentally
Input Resistance	100KΩ
Resolution	14 Bit

A.6.3 Auxiliary Feedback Port (output mode YA[4]= 4)

Feature	Details
Emulated output	▪ A, B, Index ▪ Single ended
Output current capability	Maximum output current: I_{OH} (max) = 2 mA High level output voltage: V_{OH} > 3.0 V Minimum output current: I_{OL} = 2 mA Low level output voltage:V_{OL} < 0.4 V
Available as options	▪ Emulated encoder outputs of analog encoder ▪ Emulated encoder outputs of the resolver
Maximum frequency	f_{MAX} : 5 MHz pulses/output
Edge separation between A & B	Programmable number of clocks to allow adequate noise filtering at remote receiver of emulated encoder signals
Index (marker):	Length of pulse is one quadrature (one quarter of an encoder cycle) and synchronized to A&B

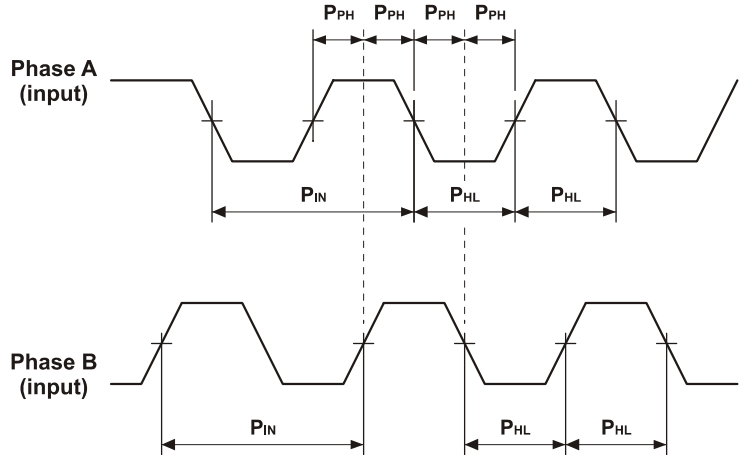


Figure A-2: Auxiliary Feedback - Encoder Phase Diagram

A.6.4 Auxiliary Feedback Port (input mode YA[4]= 2, 0)

Feature	Details
Encoder input, pulse and direction input	▪ A, B, Index ▪ Single ended
Output current capability	V_{In} Low: 0V < V_{IL} < 0.8V V_{In} High: 2V < V_{IH} < 5V Maximum absolute voltage: 0 < V_{In} < 5.5V Input current: ±1µA
Available as options	▪ Single-ended Encoder inputs ▪ Pulse and Direction inputs
Edge separation between A & B	Programmable number of clocks to allow adequate noise filtering at remote receiver of emulated encoder signals
Index (marker):	Length of pulse is one quadrature (one quarter of an encoder cycle) and synchronized to A&B

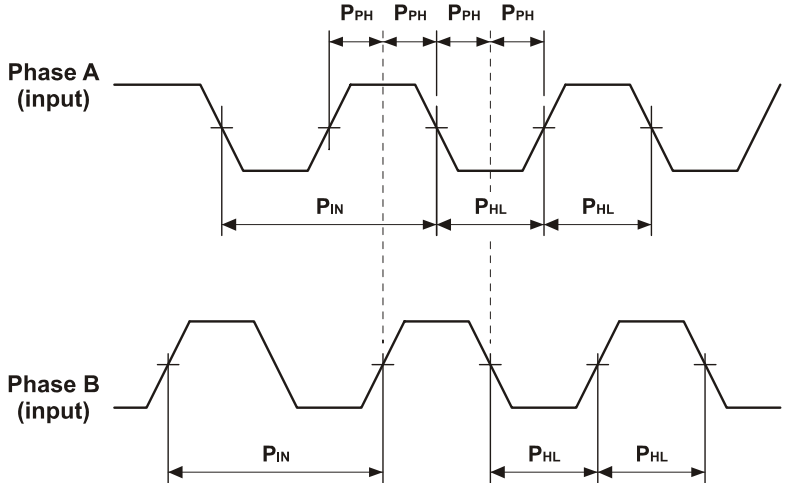


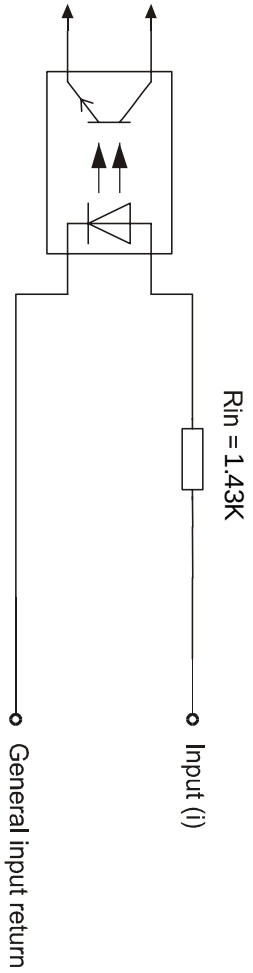
Figure A-3: Auxiliary Feedback - Encoder Phase Diagram

A.7 I/Os

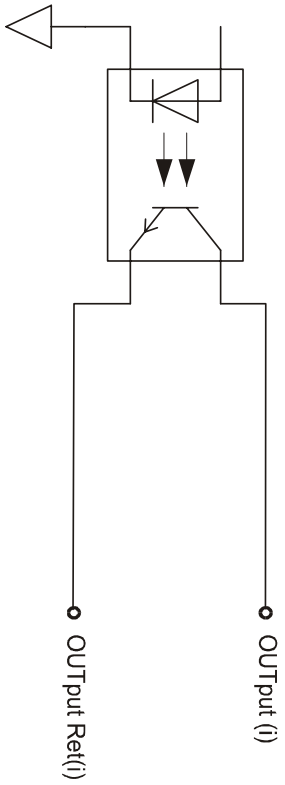
The Hornet and Bee have: 6 Digital Inputs 2 Digital Outputs 1 Analog Input

A.7.1 Digital Input Interfaces

Feature	Details	Connector Location
Type of input	▪ Optically isolated ▪ All six inputs share one signal return line	
Input current for all inputs	Iin = 2.4 mA @ Vin = 5 V	

Feature	Details	Connector Location
High-level input voltage	2.5V < Vin < 10 V, 5 V typical	 **Digital Input Schematic**
Low-level input voltage	0V < Vin < 1 V	
Minimum pulse width	> 4 x TS, where TS is sampling time	
Execution time (all inputs): the time from application of voltage on input until execution is complete	If input is set to one of the built-in functions — Home, Inhibit, Hard Stop, Soft Stop, Hard and Soft Stop, Forward Limit, Reverse Limit or Begin — execution is immediate upon detection: 0<T<4xTS If input is set to General input, execution depends on program. Typical execution time: ≅ 0.5 msec.	
High-speed inputs – 5 & 6 minimum pulse width, in high-speed mode	T < 5 µsec **Notes:** ▪ Home mode is high-speed mode and can be used for fast capture and precise homing. ▪ High speed input has a digital filter set to same value as digital filter (EF) of main encoder. ▪ Highest speed is achieved when turning on optocouplers.	

A.7.2 Digital Output Interface

Feature	Details	Connector Location
Type of output	▪ Optically isolated ▪ Open collector and open emitter	 **Digital Output Schematic**
Maximum supply output (Vcc)	30 V	
Max. output current Iout (max) (Vout = Low)	Iout (max) ≤ 10 mA	
VOL at maximum output voltage (low level)	Vout (on) ≤ 0.3 V	
RL	External resistor RL must be selected to limit output current to no more than 10 mA. $R_L = \frac{Vcc - VOL}{Io(\max)}$	
Executable time	If output is set to one of the built-in functions — Home flag, Brake or AOK — execution is immediate upon detection: 0 < T < 4 x TS If output is set to General output and is executed from a program, the typical time is approximately 0.5 msec.	

A.7.3 Analog Input

Feature	Details
Maximum operating differential voltage	± 10 V
Maximum absolute differential input voltage	± 16 V
Differential input resistance	3.74 KΩ
Analog input command resolution	14-bit

A.8 Communications

Specification	Details
RS-232	**Signals:** ▪ RxD , TxD , Gnd ▪ Full duplex, serial communication for setup and control. ▪ Baud Rate of 9,600 ~ 57,600 bit/sec.
CANopen	**CANbus Signals:** ▪ CAN_H, CAN_L, CAN_GND ▪ Maximum Baud Rate of 1 Mbit/sec. **Version:** ▪ DS 301 V4.01 **Layer Setting Service and Protocol Support:** ▪ DSP 305 **Device Profile** (drive and motion control)**:** ▪ DSP 402

A.9 Pulse Width Modulation (PWM)

Feature	Details
PWM resolution	12-bit
PWM switching frequency on the load	2/Ts (factory default 22 kHz on the motor)

A.10 Standards Compliance

A.10.1 Quality Assurance

Specification	Description
ISO 9001:2000	Quality Management

A.10.2 Design

Specification	Description
In compliance with **MIL-STD-704**	Aircraft, Electric Power Characteristics
In compliance with **MIL-STD-810**	Environmental Engineering Considerations and Laboratory Tests
In compliance with **MIL-STD-1275**	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles
In compliance with **MIL-STD-461**	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
In compliance with **MIL-HDBK-217**	Reliability Prediction of Electronic Equipment

▪ **IPC-D-275** ▪ **IPC-SM-782** ▪ **IPC-CM-770** ▪ **UL508c** ▪ **UL840**	Reliability prediction of electronic equipment (rating, de-rating, stress, etc.) Printed wiring for electronic equipment (clearance, creepage, spacing, conductors sizing, etc.)
In compliance with **VDE0160-7 (IEC68)**	Type testing

A.10.3 Safety

Specification	Description
In compliance with **UL508c**	Power conversion equipment
In compliance with **UL840**	Insulation coordination, including clearance and creepage distances of electrical equipment
In compliance with **UL60950**	Safety of information technology equipment, including electrical business equipment
In compliance with **EN60204-1**	Low voltage directive, 72/23/EEC

A.10.4 EMC

Specification	Description
In compliance with **EN55011** and **EN61000**	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment. Electromagnetic compatibility (EMC)

A.10.5 Workmanship

Specification	Description
In compliance with **IPC-A-610**, level 3	Acceptability of electronic assemblies

A.10.6 PCB

Specification	Description
In compliance with **IPC-A-600**, level 2	Acceptability of printed circuit boards

A.10.7 Packing

Specification	Description
In compliance with **EN100015**	Protection of electrostatic sensitive devices

A.10.8 WEEE*

Specification	Description
In compliance with **2002/96/EC**	Waste Electrical and Electronic Equipment

	regulations

* Please send out-of-service Elmo drives to the nearest Elmo sales office.

A.10.9 RoHS

Specification	Description
In compliance with **2002/95/EC** (effective July 2006)	Restrictions on Application of Hazardous Substances in Electric and Electronic Equipment

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